H A Pollard
J. Vaith 1830
1843

A

GRAMMAR

OF

ASTRONOMY,

WITH

PROBLEMS ON THE GLOBES:

TO WHICH ARE ADDED

A Glossary of Terms,

AND

QUESTIONS FOR EXAMINATION:

DESIGNED FOR THE USE OF

SCHOOLS AND ACADEMIES.

BY J. TOWLE.

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PREFACE.

On the subjects of Astronomy and the Globes, though several valuable but expensive treatises are already before the public, the compiler of the following pages has experienced no little inconvenience for want of a concise work adapted to the business of teaching, and to the comprehension of beginners.

The astronomical part of this little treatise is intended to prepare the learner to solve the problems understandingly.

It is unnecessary to burden the reader with preliminary observations. The intelligent can better judge of the merits of a work by a candid perusal, than by all the arguments that can be offered in its favour.

THE AUTHOR.

New-York, 1825.

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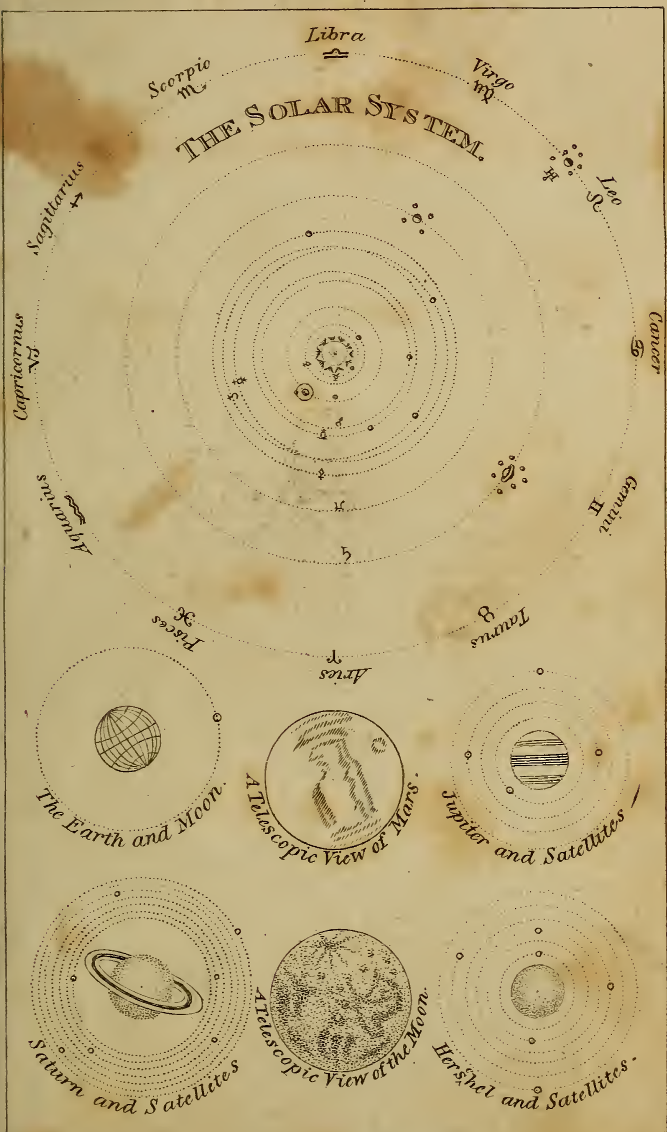

THE SOLAR SYSTEM.
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Cancer
Gemini
Taurus
Aries
Pisces
Aquarius
Capricornus
Sagittarius
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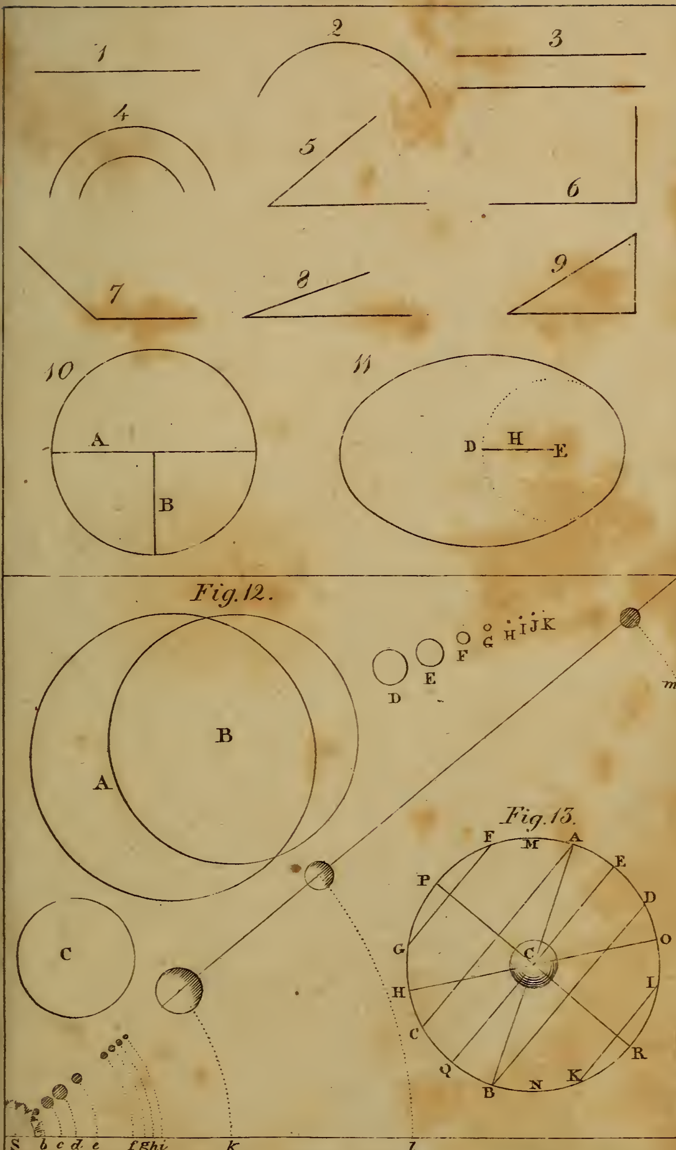

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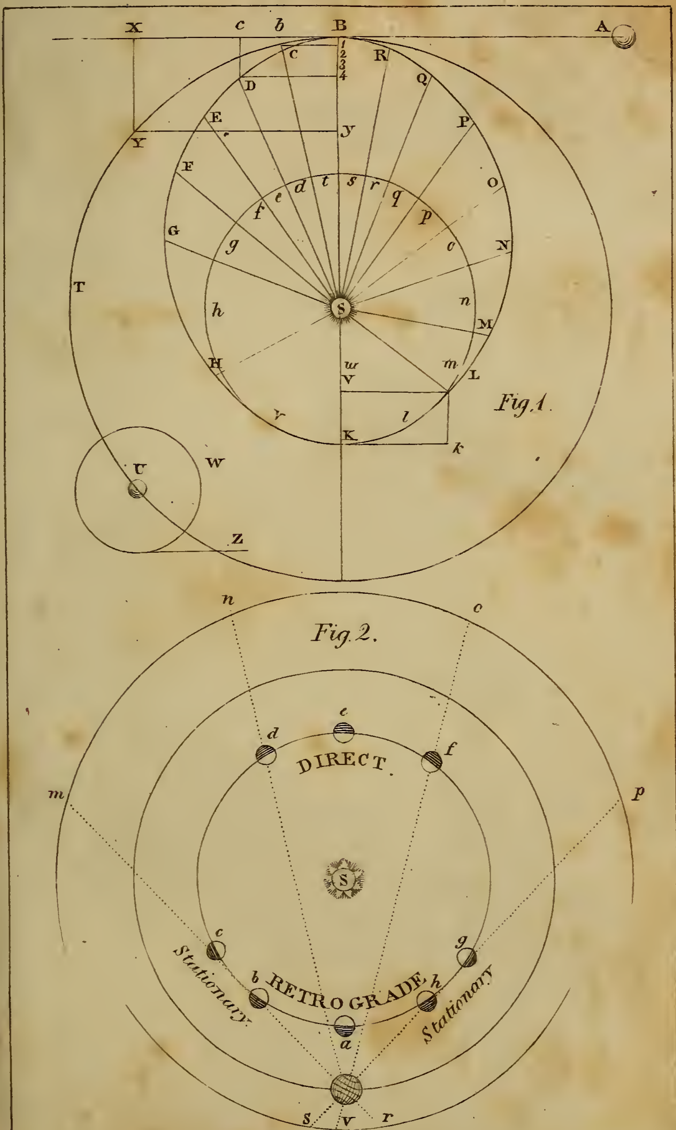

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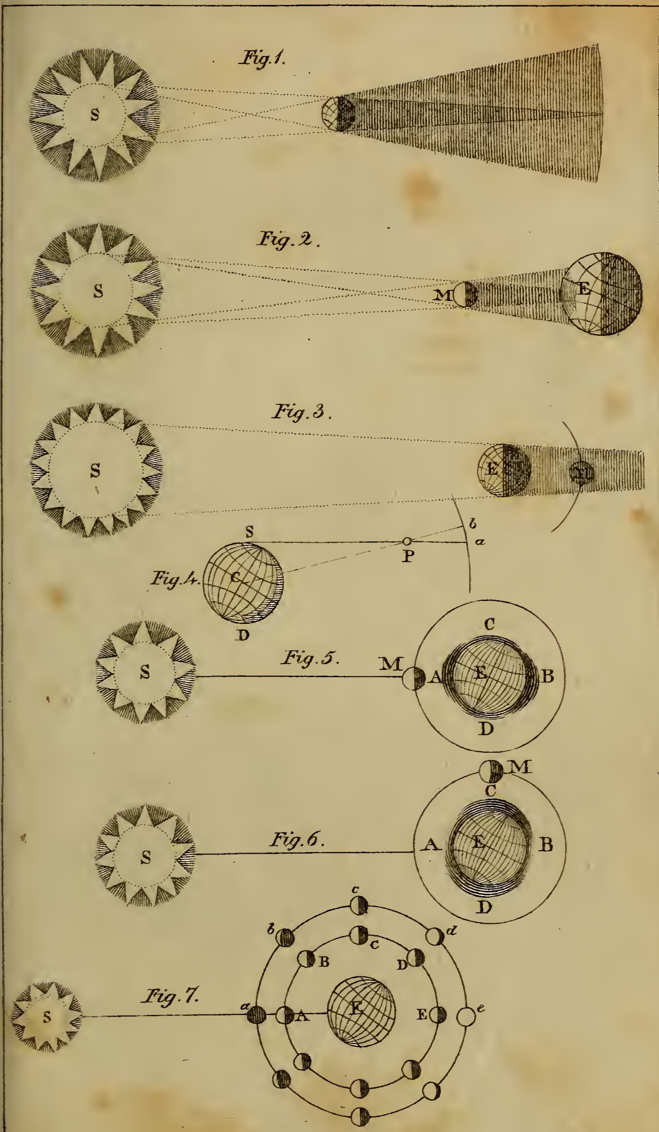
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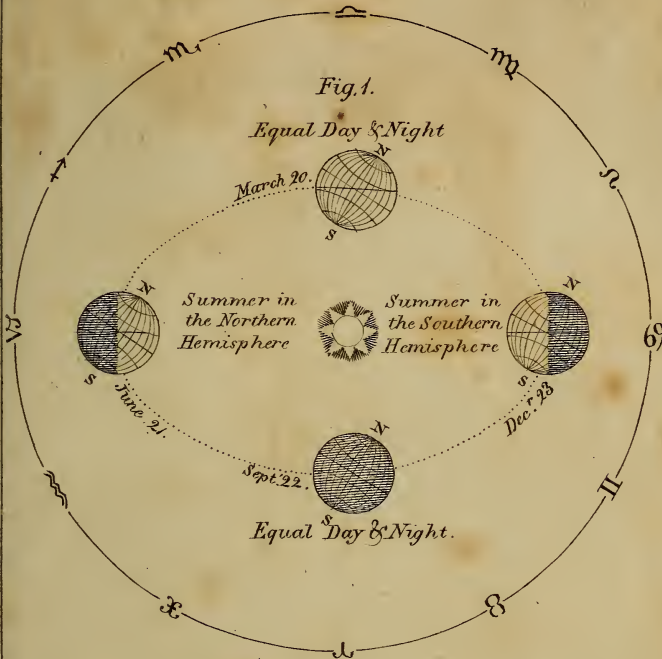

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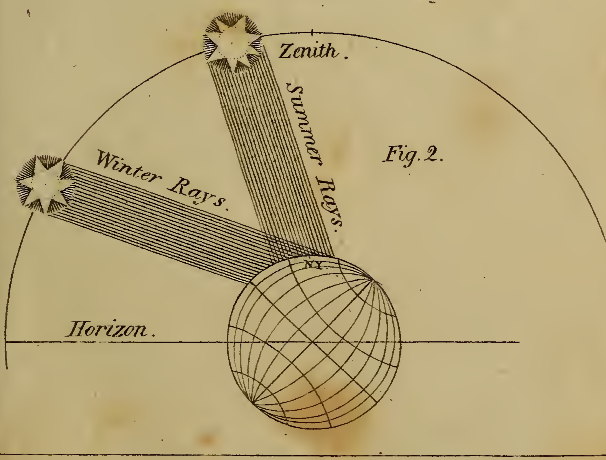

Fig. 2.

Grammar of Astronomy.

Astronomy is a mixed mathematical science, which explains the shapes, magnitudes, movements, distances, periods, and various phænomena, of the celestial luminaries.

The celestial luminaries are the sun, planets, stars, and comets.

CHAPTER I.

Of the History of Astronomy.

1 Astronomy was cultivated, at an early period, by the Chaldeans, Egyptians, Phœnicians, Greeks, Arabians, and Chinese.

2. It was studied, in a particular manner, in Chaldea; thence it passed into Egypt; and soon after into Phœnicia, where it was applied to the uses of navigation, which enabled this people to excel others in commerce.

3. The particular object of their observations, was the north polar star.

4. These observations were at length brought into Greece by Thales, who taught the theory of the motion of the sun, which accounted for the difference in the length of days, the number of days in a solar year, the theory of eclipses, and the art of foretelling them.

5. To Anaximander, the disciple of Thales, Pliny and Diogenes Laertius ascribed the invention of the terrestrial globe, or according to Strabo, geographical maps.

6. By these instructions, the Greeks were enabled to make considerable voyages, and to plant colonies in different countries. They much improved their knowledge, by an intercourse with the Pythagorean philosophers of Italy, the Druids, and the Egyptians; Alexandria being, for a long time, the seat of astronomical literature.

7. The Romans encouraged Astronomy, and endeavoured to carry it nearer to a state of perfection.

8. The Arabian princes made some exertions to promote its cultivation; and it was at length brought to its present state of perfection, by the laudable exertions of modern Europeans.

9. Among the ancient astronomers, Pythagoras and Ptolemy were the most noted. Pythagoras flourished about 590 years before Christ. In his system of the universe, the sun was placed in the centre, around which the planets were supposed to move. The planets then known, were Mercury, Venus, the Earth, Mars, Jupiter, and Saturn.

10. Ptolemy, the Egyptian astronomer, flourished 130 years after Christ. He supposed the earth to be at rest in the centre, around which moved the sun and planets, once a day, in circular orbits, in the following order; viz., the Moon, Mercury, Venus, the Sun, Jupiter, and Saturn; beyond these were placed the fixed stars.

11. From that time, Astronomy was much neglected, until near the close of the 13th century, when Alphonsus, king of Castile, formed more accurate tables than had been before known.

12. In the 16th century, this science began to assume a rational appearance, by the system of Copernicus, which was afterwards perfected by Kepler and Galileo.

13. Nicholas Copernicus, a native of Poland, revived the ancient Pythagorean system, A. D. 1530. His work was published in 1543; a copy of which was handed him a few hours before his death.

14. This system met with much opposition; and Galileo was thrown into the prison of the Inquisition for supporting it; nor was he âble to regain his liberty, without first rejecting these opinions.

15. These bigots were not his only adversaries: for even Tycho Brahe, the great Danish astronomer, was so prejudiced as to reject this discovery. From the experiment, that a stone being dropped from a lofty tower, fell perpendicularly to its base, he inferred that the earth is at rest; forgetting that a stone, being dropped from the top of a ship's mast while she is under sail, will fall directly to its foot.

16. Tycho projected another system, in the centre of which he placed the Earth, and supposed the sun, moon, and stars, to move around it; after which, he made Mercury, Venus, Mars, Jupiter, and Saturn, revolve around the Sun.

17. These monstrous absurdities died with their projector; but we must still do him the credit to say, that his other calculations were far more accurate than any that preceded them.

18. By the help of Tycho's labours, John Kepler, a German astronomer, confirmed the true system of the universe, and discovered the laws which regulate motion.

19. Galileo of Florence, is said to have been the first who made use of the telescope, and by its assistance, discovered many new phænomena; as the different phases of Saturn, the satellites of Jupiter, their motion, the uneven surface and mountains of the moon, the spots of the sun, and its revolution about its axis.

20. We owe much to the labours of the indefatigable Mr. Flamstead, to Dr. Hally, Olbers, Piazzi, Harding, and others; but, perhaps, more to the great Sir Isaac Newton and Dr. Herschel, than to all their predecessors together.

CHAPTER II.

Of the Solar System.

1. THE system of the celestial bodies, now universally received as the true one, is called the *Solar*, or *Copernican* System. As we have before stated, it was first taught by Pythagoras, 590 years before the Christian era; but it was afterwards rejected, until the sixteenth century, when it was revived by Copernicus, from whom it received its name.

2. It comprises the sun, eleven primary, and eighteen secondary planets; besides a number of comets.

3. The *primary planets* are those which revolve around the Sun as a centre; viz., 1. Mercury ☿, 2. Venus ♀, 3. Earth ⊕, 4. Mars ♂, 5. Vesta ⚶, 6. Juno ⚵, 7. Ceres ⚳, 8. Pallas ⚴, 9. Jupiter ♃, 10. Saturn ♄, 11. Herschel ♅.

4. Four of the primary planets, namely, Vesta, Juno, Ceres, and Pallas, are called *asteroids*. They are but minor planets.

5. The *secondary planets* are those which revolve round the primary planets. The earth has 1, called the moon; Jupiter has 4; Saturn, 7; and Herschel, 6.

6. *Comets* are wandering bodies, which revolve round the sun, in very eccentric orbits; and are only seen when in that part of their orbit nearest the sun.

7. The Sun is the centre of the system; around which all the primary planets move, in their respective orbits, from west to east, attended by their secondaries or moons.

8. The *orbit* of a celestial body, is the line which it describes in performing its revolution round the sun, or its primary planet. The orbits of the planets are elliptical. [See *Ellipsis*, Glossary.]

9. The time which a planet takes to revolve round the sun, is called its *year;* and the time which it takes to revolve on its axis, its *day*.

10. The *axis* of a planet, is an imaginary line passing through its centre, on which it is supposed to revolve.

11. The sun and all the planets are of a globular form, though not perfect globes.

12. A *globe*, or *sphere*, is a body perfectly round, having every part of its surface exactly the same distance from the centre.

13. The sun and planets are known to be of a globular form, because they bear that appearance to the naked eye; and from the circumstance of their casting a circular shadow, during the time of an eclipse.

14. Several things combine to prove that the form of the earth is globular. 1. Navigators by steering their course directly westward, arrive at

the same place whence they departed. 2. The north polar star becomes more elevated as you travel north. 3. The mast of an approaching ship is visible before the hull; which proves the convexity of the sea.

15. The *Zodiac* is that part of the heavens, comprising the paths in which the planets move. It is divided into 12 equal parts, called signs; viz., Aries ♈, Taurus ♉, Gemini ♊, Cancer ♋, Leo ♌, Virgo ♍, Libra ♎, Scorpio ♏, Sagittarius ♐, Capricornus ♑, Aquarius ♒, and Pisces ♓.— These are 12 constellations of stars, through which the planets appear to pass.

16. The *Ecliptic* is the orbit of the earth around the sun. All the planets are supposed to cross the ecliptic, in two opposite points, called nodes

CHAPTER III.

Of the Sun, ☉.

1. This grand luminary is a spherical body, situated in the centre of the planetary system. Its diameter is 883,246 miles. It performs a revolution about its axis in 25 days 14 hours 8 minutes; and dispenses light and heat to all the planets, in proportion to their distances.

2. The sun is nearer to the earth in the winter season, than in the summer.

3. The sun's diameter forming different angles with us, at different times, is a proof that the earth moves round the sun, in an elliptical orbit; and the reason that it is hotter in summer than in winter, is because the sun's rays fall more obliquely on us in winter than they do in summer.

4. It is supposed that an atmosphere environs

the sun, and that its light and heat are occasioned by a gaseous combustion of a phosphoric nature, which takes place in the surrounding atmosphere.

5. The atmosphere by which the sun is surrounded, is supposed to extend about 2000 miles from its surface; and its density to be at least eighty times greater than that which environs the earth.

6. The appearance of the sun's rising in the east, and setting in the west, is occasioned by the rotation of the earth on its axis.

7. When the sun is on the meridian of any place, it is *noon* at that place; and at the opposite meridian it is *midnight*.

8. The period in which the sun revolves on its axis, has been ascertained by means of several dark spots viewed through a telescope. In the same manner have the rotary periods of Mars, Venus, and Jupiter, been ascertained; hence it is supposed that all the planets have the same motion.

Obs. Sir Isaac Newton observes of the sun, 1. That its heat is seven times greater in Mercury, than with us; and that water there would be carried off in steam: 2. That the quantity of matter in the sun, is to that in Jupiter, as 1100 is to 1: and that the distance of Jupiter from the sun, is in the same ratio of the sun's diameter; consequently the centre of gravity of the sun and Jupiter, is nearly in the superficies of the former: 3. That the quantity of matter in the sun, is to that in Saturn, as 2360 to 1; and the distance of Saturn from the sun, is in a ratio little less than that of the sun's semidiameter; whence the common centre of gravity of Saturn and the sun, is a little within the latter: therefore the common centre of gravity of all the planets, cannot be more than the length of the solar diameter from the centre of the sun: 4. The sun's diameter is equal to 100 diameters of the earth, and the whole body exceeds that of the

earth a million of times: 5. If 360 degrees be divided by the quantity of the solar year, it gives 59′ 1″, and the horary motion is 2′ 27″.

CHAPTER IV.

Of Mercury, ☿.

1. MERCURY is the nearest planet to the sun, his mean distance being about 37,000,000 of miles. He has a bright bluish appearance.

2. The diameter of Mercury is 3,224 miles.

3. His revolution is performed in 87 days 23 hours; which is the length of his year.

4. Mercury revolves on his axis in about 24 hours, or nearly the same time in which the earth revolves: this makes his day about the same length as ours.

5. In his orbit, Mercury crosses the plane of the ecliptic in Taurus 15°, and in Scorpio, 15°: thus his ascending node is in 15° of Taurus, and his descending node in 15° of Scorpio. His greatest elongation is 28°.

6. The velocity of this planet in its orbit, is at the mean rate of 109,500 miles an hour. Its eccentricity is 7,000,000 of miles.

7. By *eccentricity* is understood the distance between the centre of an ellipsis and either of its foci.

8. When viewed through a good telescope, Mercury assumes the different phases, or changes of the moon.

9. When Mercury passes exactly between the earth and the sun, he appears on the sun's disk like a small dark spot, or speck. This is called a

transit. Only three transits of Mercury have been observed.

10. By the sun's *disk*, is meant the round face of the sun, which, from its distance, appears flat.

CHAPTER V.

Of Venus, ♀.

1. VENUS is the second planet in the system. Her situation is immediately within the orbit of the earth. Her brilliancy is greater than that of any other planet; and she frequently causes the objects on which she shines to cast a shadow. Venus may sometimes be seen at noonday.

2. The diameter of Venus is 7,687 miles; and her circumference about 24,200 miles.

3. Her mean distance from the sun is 68,000,000 of miles; her eccentricity, 473,100 miles; and she moves in her orbit at the mean rate of 89,000 miles an hour.

4. The annual revolution of Venus is performed in about 224 days; and her diurnal rotation, in about 23 hours 21 minutes.

5. Venus, like Mercury, has phases similar to those of the moon.

6. Transits of Venus sometimes happen, though but seldom. A transit over the sun's disk, was first observed Nov. 16, 1739.

7. Two transits of Venus will occur in the present century: the former, Dec. 8, 1874, and the latter, in 1882.

8. Venus is sometimes seen as an evening star, and sometimes as a morning star. When she is in the upper part of her orbit, and rises before the

sun, she is a morning star; and when she is in the lower part of her orbit, and sets after the sun, an evening star.

9. There have been observed bright and dark spots on the disk of Venus: there are also mountains; some of which are supposed to be six times higher than any on the earth.

10. The orbit of Venus intersects the plane of the ecliptic in 15° of Gemini, and in 15° of Sagittarius. These are her ascending and descending nodes.

11. She is surrounded with atmosphere, which has been calculated to be 50 miles in height.

CHAPTER VI.

Of the Earth, ⊕.

1. The Earth, which we inhabit, is the third planet from the sun: it is situated between the orbits of Venus and Mars. In shape it is an oblate spheroid, elevated at the equator, and depressed at the poles.

2. The mean distance of the earth from the sun, is computed to be 95,000,000 of miles. It moves in its orbit at the rate of 68,000 miles an hour.

3. The equatorial diameter of the earth, is 7,924 miles; which exceeds the polar diameter by 37 miles. The eccentricity of its orbit is 1,618,000 miles.

4. The circumference of the earth, measured round the equator, is 24,904 miles, and through the poles, 24,773 miles.

5. The earth performs its sidereal revolution

around the sun in 365 days 6 hours 9 minutes 12 seconds; and its tropical, in 365 days 5 hours 48 minutes 49 seconds; and revolves on its axis in 24 hours.

6. The *sidereal revolution* of the earth, is the time it occupies in passing from any fixed star, till it arrives at the same star again; and its *tropical revolution* is the time it takes in travelling through the fixed signs of the zodiac; which is the length of the natural year.

7. In the movement of the earth in its orbit, the equinoctial points fall back, in a retrograde motion, from east to west, about 50¼ seconds of a degree, or 20 minutes 23 seconds of time every year: this retrograde motion is called the *recession* or *precession of the equinoxes.*

8. The length of the natural day is 24 hours, it being the time which elapses from the sun's appearing on any meridian, to the time in which it is seen on the same meridian again.

9. A *meridian* is a great circle of the sphere, which passes through the zenith and poles, perpendicular to the horizon.

10. The motions of the earth are three; the annual, the diurnal, and the recession of the equinoxes.

11. The inclination of the earth's axis in its orbit, produces the variety in the seasons; namely, Spring, Summer, Autumn, and Winter; and its rotation on its axis produces the succession of day and night.

12. The ecliptic makes an angle of 23° 28′ with a plane passing through the equator of the earth: this is called the *obliquity of the ecliptic.*

13. As the ecliptic is the apparent path of the sun, it will readily be perceived, that his greatest

apparent declination from the equator, either north or south, can never exceed 23° 28′.

14. This apparent declination of the sun, is not occasioned by his own motion, but by the peculiar situation of the earth with respect to the sun.

15. When the sun is in his greatest apparent declination north, the days are longest in a northern, and shortest in a southern latitude; this happens on the 21st of June, at which time the sun shines 23° 28′ over the north pole.

16. When the sun is in his greatest apparent declination south, the days are longest in a southern, and shortest in a northern latitude; this happens on the 21st of December. The sun then shines 23° 28′ over the south pole.

17. The portions of the ecliptic in which the earth appears on those days, are called the *solstitial points;* these are the first degree of Cancer, and the first degree of Capricornus.

18. At the time of the equinoxes, that is, when the sun has no apparent declination, but shines equally on both poles, the days and nights are equal in length all over the earth. This happens twice a year, namely, on the 21st of March, and on the 21st of September.

19. When the earth is in that part of its orbit where both the north and the south pole receive the sun's rays at the same time, it is said to be in its *equinox.* This happens when the sun appears in the constellations of Aries and Libra, the first degrees of which are called the *equinoctial points.*

20. The declination is greatest at the solstices, and nothing in the equinoxes.

21. The earth is in 1° of Aries, on the 22d of September; 1° of Taurus, on the 24th of October; 1° of Gemini, on the 23d of November;

1° of Cancer, on the 21st of December; 1° of Leo, on the 21st of January; 1° of Virgo, on the 19th of February; 1° of Libra, on the 21st of March; 1° of Scorpio, on the 21st of April; 1° of Sagittarius, on the 21st of May; 1° of Capricornus, on the 21st of June; 1° of Aquarius, on the 24th of July; and 1° of Pisces, on the 24th of August. The sun always appears in the opposite signs.

Obs. The ecliptic being inclined to an angle of 23° 28′ from the equator, the earth, in passing through it, must be at different distances from the plane. The nearest distance from this plane to the sun's vertical rays, is the *earth's* declination, commonly called the sun's declination.

22. To the height of 45 or 50 miles, the earth is surrounded by a collection of vapours, called *atmosphere*, which is the support of animal life.

23. The earth is attended by one secondary planet, or satellite, called the *moon*, which, in the sun's absence, dispenses light to the earth, though in a less degree than the sun.

CHAPTER VII.

Of Mars, ♂.

1. Mars, the fourth planet in order from the sun, is of a dusky red appearance, owing probably to the density of his atmosphere. Like Mercury and Venus, he is sometimes in conjunction with the sun, but never transits the sun's disk.

2. When viewed through a telescope, Mars sometimes appears full and round; at other times gibbous, but never horned. His apparent motion

is sometimes direct, or from east to west; sometimes retrograde; and at others, he appears stationary.

3. Mars performs his annual revolution in about 687 days, at the mean distance of 144,000,000 of miles from the sun. The length of his diameter is computed to be 4,189 miles, and the eccentricity of his orbit, 13,463,000 miles. He moves at the mean rate of 55,000 miles an hour.

4. The diurnal rotation of Mars on his axis, is performed in about 24 hours, nearly the same time in which the earth performs its rotation.

5. The orbit of Mars makes an angle of 1° 52′ with the plane of the ecliptic. The place of his ascending node is in 18° of Taurus.

6. When Mars rises before the sun, he is seen in the morning; but when he sets after the sun, he is seen in the evening.

7. It is evident that the orbit of Mars is without that of the earth, as he is sometimes seen opposite to the meridian at noonday.

8. The earth would appear to the inhabitants of Mars, as Venus appears to us.

CHAPTER VIII.

Of the four Asteroids, or Minor Planets.

1. Vesta, one of the minor planets, was discovered by Dr. Olbers, of Bremen, in Lower Saxony, March 29, 1807. It is visible to the naked eye, only in very clear evenings. It shines with a pure white light, and appears like a star of the fifth magnitude.

2. The diameter of Vesta is computed to be 238 miles; and its mean distance from the sun, 225,000,000 of miles. It revolves round the sun in about 3 years 60 days, at the mean rate of 44,201 miles an hour. The eccentricity of its orbit is 30,000,000 of miles; but the time which it takes to perform a revolution on its axis, is not known.

3. Juno was discovered by Mr. Harding, near Bremen, on the 1st of September, 1804. It is situated between the orbits of Vesta and Pallas, and shines with a brilliant light, owing probably to certain changes in the density of its atmosphere.

4. The diameter of Juno is computed to be 1,425 miles; and its mean distance from the sun, 252,000,000 of miles. It performs its annual revolution in 4 years 128 days, at the rate of 41,170 miles an hour. Its eccentricity is 68,000,000 of miles.

5. Ceres, the next planet to Juno, was discovered by M. Piazzi of Palermo, in the island of Sicily, January 1, 1801. It exhibits a ruddy appearance, owing to the dense atmosphere by which it is surrounded; and, to the naked eye, its size is that of a star of the sixth magnitude.

6. The diameter of Ceres is 1,024 miles; and its mean distance from the sun is about 263,000,000 of miles. It revolves around the sun in 1,681 days 12 hours 9 minutes, or about 4 years 221 days, at the mean rate of 40,930 miles an hour. The eccentricity of its orbit is computed to be 20,598,130 miles.

7. The height of its atmosphere, according to Shroeter, the German astronomer, is 676 miles.

8. Pallas was discovered by Dr. Olbers of Bre-

men, March 28, 1802. Its appearance is not so ruddy as that of Ceres, by reason of the less extent of its atmosphere, which is computed to be 468 miles in height.

9. Shroeter estimates the diameter of Pallas at 2,099 miles; and its distance from the sun, 265,000,000 of miles.

10. It performs its revolution round the sun in 1,703 days, at the rate of 40,930 miles an hour; and its eccentricity is about 64,516,673 miles.

11. The orbit of Pallas crosses that of Ceres, in consequence of the great eccentricity of the former.

Obs. As the great space between the orbits of Mars and Jupiter, does not, without another planet, seem to agree with the harmony of proportionable distance in the solar system, the four minor planets are supposed, by some astronomers, to have been separated from one original planet, by some convulsion in nature, capable of destroying the mutual attraction of the fragments. It is evident that the smaller parts would, by the explosive force, be thrown to the greatest distance from the original orbit, while the greater fragments, on account of their gravity, deviate less from the original path of the primary body. Thus Pallas and Juno are supposed by some to be less than Ceres and Vesta, because of their greater eccentricity.

CHAPTER IX.

Of Jupiter, ♃.

1. Jupiter, the next planet in order, and the largest in the solar system, is situated between the orbits of Pallas and Saturn.

2. The diameter of Jupiter is about 89,170

miles; and his mean distance from the sun, about 490,000,000 of miles.

3. Jupiter performs his annual revolution around the sun in 4,330 days 14 hours 19 minutes, or about 19 years $10\frac{2}{3}$ months, at the mean rate of 298,660 miles an hour.

4. Jupiter revolves on his axis in 9 hours 55 minutes 39 seconds, consequently his night can never be 5 hours in length.

5. As the axis of this planet has no inclination, there is no change in its seasons.

6. In the polar regions of Jupiter, there is perpetual winter; and about the equator, perpetual summer.

7. The appearance of Jupiter is bright, but, by reason of his greater distance, is less so than Venus.

8. When Jupiter is seen west of the sun, he has the appearance of a morning star; but when seen east of the sun, he has the appearance of an evening star.

9. In his orbit, Jupiter forms an angle of 1° 20′ with the plane of the ecliptic.

10. The sun appears five times larger to us, than it does to the inhabitants of Jupiter; consequently their light and heat are less in proportion.

11. Jupiter appears to be surrounded with belts, which are supposed to be clouds floating in his atmosphere. These belts are always parallel to his equator, and are interspersed with dark spots, which are supposed to be clouds more dense than the others. By observing these spots through a telescope, the time of Jupiter's rotation on his axis has been ascertained.

12. This planet is constantly attended by 4

satellites, or moons, which revolve about it, and compensate, in part, for the want of light, occasioned by its remoteness from the sun.

CHAPTER X.

Of Saturn, ♄.

1. Saturn is situated between the orbits of Jupiter and Herschel, and revolves around the sun, from which his mean distance is 960,000,000 of miles.

2. The diameter of Saturn is 79,042 miles; and his circumference, about 244,137 miles.

3. Saturn performs his annual revolution around the sun, in 10,746 days 19 hours 16 minutes, or about 29 years and a half; and moves at the mean rate of about 22,000 miles an hour.

4. The orbit of Saturn forms an angle of 2° 30′ with the plane of the ecliptic. His eccentricity is estimated at 49,000,000 of miles. His ascending node is 22° of Cancer; and his descending node, 22° of Capricornus.

5. This planet performs a daily revolution on its axis in 10 hours 16 minutes 2 seconds.

6. To the naked eye, it appears like a star of the second magnitude. In consequence of its great distance from the sun, the light which it reflects, is less than that of Jupiter.

7. When viewed through a good telescope, Saturn exhibits a beautiful appearance, being decorated with various belts, interspersed with spots, and encompassed by a bright luminous double ring, which very much resembles the wooden horizon of an artificial globe.

8. The ring has a motion on its axis, and casts a shadow on the surface of the planet, which leads some to suppose that it is solid. It was discovered in 1609, by Galileo. It revolves about Saturn in 10 hours 33 minutes.

9. The distance between Saturn and his inner ring, is 21,000 miles; and between the inner and the outer ring, 2,839 miles. The inner ring being 2,000 miles in breadth, and the outer, 7,200 miles, the whole distance from the surface of Saturn to his outward boundary, is 51,039 miles.

10. The belts, or zones of Saturn, are similar to those of Jupiter, and their appearance may be attributed to the same causes, namely, to clouds floating in their respective atmospheres.

11. There have been various conjectures concerning the substance of Saturn's ring. Some have supposed it to be composed of a vast assemblage of planets; others have supposed it to be a permanent bright cloud.—Whatever may be its substance, it undoubtedly reflects the light of the sun on the planet.

12. Saturn has 7 moons, or satellites, which constantly attend him in his grand revolution around the sun. Five of these satellites were discovered by Cassini and Huygens; and the other two, by the celebrated Dr. Herschel, with his telescope, which magnified not less than 6,000 times.

CHAPTER XI.

Of Herschel, ♅.

1. Herschel, the last planet in the solar system, and most distant from the sun, was discovered by

Dr. Herschel, at Bath, in England, March 13, 1781. It shines with a bluish white light, and is seldom seen without the aid of a telescope of great magnifying power.

2. The diameter of this planet is 35,112 miles; and its mean distance from the sun, about 1,800,000,000 of miles.

3. It performs its annual revolution around the sun in 30,637 days 4 hours, or 84 years 2 months and a half. The time which it occupies in performing a revolution on its axis, has not yet been determined. In its orbit, it moves at the mean rate of about 15,546 miles an hour.

4. The orbit of Herschel is nearly parallel with the plane of the ecliptic, forming an angle of only 46′. His eccentricity is 84,800,000 miles. His ascending node is 12° of Gemini; and his descending node 12° of Sagittarius.

Obs. The name given to this planet, by its discoverer, was Georgium Sidus: others on the continent have called it Uranus, as Mars was the son of Jupiter, so Jupiter was the son of Saturn, the father of whom, among the heathen deities, was called Uranus: others have, with more propriety, given it the name of Herschel, in honour of its discoverer, which name we have preferred.

5. A planet may easily be distinguished from a fixed star; for the former shines with a steady light, but the latter is constantly twinkling.

6. Herschel is constantly attended by six satellites, or moons, the orbits of which are nearly perpendicular to that of their primary.

7. The light and heat which Herschel derives from the sun, is 360 times less than what is derived by the earth.

TABULAR VIEW OF THE SOLAR SYSTEM.

Names of the Planets.	*Mean diameters in English miles.*	*Mean distances from the Sun, in round numbers of miles.*	*The correct mean distances, that of the earth being 100000*	*Mean apparent diameters, as seen from the Earth.*	*Mean diameters, as seen from the Sun.*	*Densities—that of water being 1.*	*Proportional quantities of matter*	*Diurnal rotations round their own axes.*	*Inclinations of axes to orbits.*	*Inclinations of orbits to the ecliptic in 1780.*
The Sun	883246			32′ 1″.5		1 2-15	333928	25*d* 14*h* 8′ 0″	82° 44′ 0″	
Mercury	3224	37,000,000	38710	10	16″	9 1-6	0.1654	14 24 5 28		7° 0′ 0″
Venus	7687	68,000,000	72332	58	30	5 11-15	0.8899	0 23 20 54		3 23 35
The Earth	7911,73	95,000,000	100000		17 .2		1	1 0 0	66 32	0 0 0
The Moon	2180	95,000,000	100000	31 8	4 .6	4 1-2	0.025	29 17 44 3	88 17	5 9 3 at a mean.
Mars	4189	144,000,000	152369	27	10	3 2-7	0.0875	0 24 39 22	59 22	1 51 0
Ceres	163 } 1024 }	263,000,000	276500	1 } 6 .4 }	- -	2	- -	- - - -	- -	10 37 0 in 1804.
Pallas	80 } 2099 }	265,000,000	279100	0 .5 } 6 .5 }	- -	2	- -	- - - -	- -	34 50 40 in 1804.
Juno	1425	252,000,000	265700	3	- -	- -	- -	27 *hours probably.*	- -	21 0 } 13 4 } in 1804.
Vesta	238	225,000,000	237300	0 .5	- -	- -	- -	- - - -	- -	7 8 46 in 1809.
Jupiter	89170	490,000,000	520279	39	37	1 1-24	312.1	0 9 55 37	90 *nearly.*	1 18 56 in 1780.
Saturn	79042	900,000,000	954072	18	16	0 13-32	97.76	0 10 16 2	60 *probably*	2 29 50 in 1780.
Herschel	35112	1,800,000,000	1908352	3 54	4	0 99-100	16.84	- - - -	- -	0 46 20 in 1780.

TABULAR VIEW OF THE SOLAR SYSTEM.

Names of the Planets.	*Tropical revolutions.*	*Sidereal revolutions.*	*Place of Aphelion in January. 1800.*	*Motion of the Aphelion in 100 years.*	*Longitude of ascending node in 1750.*	*Motion of nodes in 100 years.*	*Eccentricities; the mean distances being 100000.*	*Greatest equation of centre.*
The Sun								
Mercury	87*d* 23*h* 14′ 32″.7	87*d* 23*h* 15′ 34″.6	8*s* 14° 20′ 50″	1° 33′ 45	1*s* 15° 20′ 43″	1° 12′ 10′	7955.4	23° 40′ 0″
Venus	224 16 41 27 .5	224 16 49 10 .6	10 7 59 1	1 21 0	2 14 26 18	0 51 40	498	0 47 20
The Earth	365 5 48 49	365 6 9 12	9 8 40 12	0 19 35			1681.395	1 55 30 .9
The Moon								
Mars	686 22 18 27 .4	686 23 30 35 .6	5 2 24 4	1 51 40	1 17 38 38	0 46 40	14183.7	10 40 40
Ceres	1681 12 9		4 25 57 15 in 1802.		2 20 58 40 in 1802. 2 21 6 0 in 1804.		8141	9 20 8
Pallas		1703 16 48	10 1 7 0 in 1802.		5 22 28 57 in 1804.		24630	28 25 0
Juno	4 *years* 128 *days.*		7 29 49 33		4 21 6 0 in 1804.		25096	
Vesta	3 *years* 60 *days* 4 *hrs*		2 9 42 53		3 13 1 0		9322	
Jupiter	4330 14 39 2	4332 14 27 10 .8	6 11 8 20 in 1800.	1 34 33	3 7 55 32 in 1750.	0 59 30	25013.3	5 30 38
Saturn	10746 19 16 15 .5	10759 1 51 11 .2	8 29 4 11 in 1800.	1 50 7	3 21 32 22 in 1750.	0 55 30	53640.42	6 26 42
Herschel	30637 4 0 0	30737 18 0 0	11 16 30 31 in 1800.	1 29 2	2 12 47 in 1788.	1 44 35	90804	5 27 16

CHAPTER XII.

Of the Secondary Planets.

1. A secondary planet revolves around a primary one as a centre, in the same manner as its primary revolves around the sun.

2. Though a secondary planet gravitates principally towards its primary as a centre, yet its motion is much influenced by the attraction of the sun; consequently, the movement in its orbit is not so uniform as that of its primary.

Of the Moon.

3. The Moon is a satellite to the earth, and partially supplies it with light, in the absence of the sun. It is an opaque body, in shape nearly globular, and in size about one fifth part of the earth. Its diameter is 2,180 miles; and its circumference, about 6,851 miles.

4. The mean distance of the moon from the earth, is 240,000 miles; and from the sun, 95,000,000 of miles. It moves in its orbit around the earth, at the rate of 2,290 miles an hour.

5. The moon performs a rotation on its axis, in 27 days 7 hours 43 minutes 5 seconds, which is the length of its lunar day: this is also the length of the lunar month.

6. By the *phases* of the moon, are meant the changes observable in its shape: it is sometimes full; sometimes horned; and at others, gibbous, according to the situation of the dark side with respect to the earth.

7. *New moon* is when the moon is in *conjunc-*

tion, i. e. when it is between the earth and the sun, the dark side being presented to us.

8. *Full moon* is when it is in *opposition*, i. e. when the earth is between the sun and the moon, and the illuminated side is presented to us.

Of the Satellites of Jupiter.

9. To make up for the deficiency of light, occasioned by the great distance of Jupiter from the sun, he has 4 satellites, or moons, which revolve around him, from west to east, at different periods and distances. They were discovered by Galileo in 1610.

10. The first satellite is 252,511 miles distant from the centre of Jupiter, and revolves around him in 1 day 18 hours 27 minutes 33 seconds.

11. The second is 400,810 miles distant, and performs its revolution in 3 days 13 hours 13 minutes 42 seconds.

12. The third is 640,406 miles distant, and performs its revolution in 7 days 3 hours 42 minutes 33 seconds.

13. The fourth satellite of Jupiter is 1,126,723 miles distant, and performs its revolution in 16 days 16 hours 32 minutes 8 seconds.

14. The satellites of Jupiter are of the greatest importance in finding the longitude of places, by observing their immersion and emersion, as these take place at the same instant of time, in every part of the earth. The first satellite is considered the best for this purpose, as it is better known than the others, and its eclipses happen more frequently.

15. The immersion and emersion of Jupiter's satellites are found in the Nautical Almanac, ac-

curately calculated for the meridian of Greenwich.

16. The angles of the orbits of Jupiter's moons, as seen from the earth, are as follow: the first is 3′ 55″; the second, 6′ 14″; the third, 9′ 58″; and the fourth, 17′ 30″.

Of the Satellites of Saturn.

17. In addition to his luminous ring, Saturn has 7 satellites.

18. The first satellite is 111,534 miles distant from Saturn, and revolves around him in 22 hours 37 minutes 23 seconds.

19. The second is 139,964 miles distant, and performs its revolution in 1 day 8 hours 53 minutes 9 seconds.

20. The third is at the distance of 172,222 miles, and performs its revolution in 1 day 21 hours 18 minutes 27 seconds.

21. The fourth is at the mean distance of 216,507 miles, and performs its revolution in 2 days 17 hours 44 minutes 51 seconds.

22. The fifth performs its revolution in 4 days 12 hours 25 minutes 11 seconds, at the mean distance of 314,920 miles.

23. The mean distance of the sixth, is 708,570 miles, and it performs its revolution in 15 days 22 hours 41 minutes 16 seconds.

24. The seventh satellite of Saturn performs its revolution in 79 days 7 hours 53 minutes 43 seconds, at the mean distance of 2,125,910 miles. This last satellite of Saturn has been observed to perform a rotation on its axis, like the moon.

Of the Satellites of Herschel.

25. Herschel has 6 satellites, all of which were discovered by Dr. Herschel.

26. The first performs its revolution around its primary in 5 days 21 hours 25 minutes, at the distance of about 204,000 miles.

27. The second planet is about 290,000 miles distant, and performs its periodical revolution in 8 days 17 hours 1 minute 19 seconds. It was discovered Jan. 11, 1787.

28. The third performs its revolution in 10 days 23 hours 4 minutes. Discovered March 26, 1794.

29. The fourth is about 388,000 miles distant, and performs the period of its revolution in 13 days 11 hours 5 minutes. Discovered January 11, 1787.

30. The fifth completes its revolution in 38 days 1 hour 49 minutes, at the distance of about 777,000 miles. Discovered February 9, 1790.

31. The revolution of the sixth is completed in 107 days 16 hours 40 minutes, at the distance of about 1,500,000 miles.

32. The orbits of Herschel's satellites are said to be nearly perpendicular to the plane of the ecliptic, and to perform their revolutions in a retrograde motion, contrary to the order of the signs.

CHAPTER XIII.

Of Comets.

1. Comets are certain wandering bodies, belonging to the solar system, which move round the sun,

in very eccentric orbits. They have no visible disk, and shine with a faint nebulous light, accompanied with a train or bright streak, in a direction opposite the sun.

2. In some parts of their orbits, they approach very near the sun; and thence disappear in infinite space, receding beyond the confines of Herschel.

3. Comets appear in every region of the heavens, and move in every possible direction, sometimes travelling directly in the order of the zodiacal signs, and at others in a retrograde motion.

4. The ancients believed that comets were ominous of plagues, wars, famines, &c.; and were sent by the Deity to punish mankind for their crimes.

5. From the numerous observations made on the comet of 1680, Sir Isaac Newton concluded that, agreeably to his theory, comets revolve about the sun, but in very eccentric ellipses.

6. The movement of comets is much accelerated when moving *towards* the sun, and retarded when moving *from* it.

7. The comet of 1680, approached within about 130,000 miles of the sun; and, at its perihelium, was supposed to move at the rate of 880,000 miles an hour.

8. Comets appear to be much affected in their orbits, by the attractive action of the primary planets.

9. About 500 comets have been observed by the ancient and modern astronomers; but the elements of only 97 have been ascertained.

10. From observation, it appears that 24 comets have passed between the orbit of Mercury and the sun; 33 between the orbits of Mercury and Ve-

nus; 21 between the orbits of Venus and the earth; 15 between the orbits of the earth and Mars; 3 between the orbits of Mars and Ceres; and 1 between the orbits of Ceres and Jupiter.

11. Comets are of various magnitudes, but the greater number of them are supposed to be less than the moon.

12. Various conjectures have been entertained, respecting the bright lucid train extending from the nucleus of comets. It is most probably a thin vapour ignited by means of the sun's heat: comets must consequently be surrounded with atmosphere.

13. The system of comets is still somewhat in obscurity; but we must depend upon the opinions of Newton, Hally, Euler, Clairant, Kepler, and Sexell, until multiplied observations shall have added to the imperfect knowledge which we at present possess, respecting those singular bodies.

CHAPTER XIV.

Of the Fixed Stars.

1. Fixed stars are luminous bodies appearing stationary in the heavens, at the same distance from each other. They are supposed to be of the same substance and properties as the sun; or to be *suns* to other systems. They are at such immense distances from us, as to appear like small twinkling dots, or points.

2. The fixed stars appear to shine by their own effulgence, with an unsteady, twinkling light; whereas the light of the planets is steady, always having the same appearance.

3. The fixed stars appear to have a motion on their axes like the sun; and as the earth revolves from west to east, they appear to move from east to west.

4. As the north pole of the earth always points directly to the polar star, that star appears immovable; and its elevation above the horizon of any place, is always equal to the latitude of the place.

5. Not more than a thousand stars, above the horizon, are at once visible to the naked eye; and the appearance of so innumerable a multitude, as are observable on a clear winter's evening, is owing to the incessant twinkling, occasioned by a division of the particles of light escaping through the mists of the atmosphere.

6. The fixed stars, being at so great a distance, are not increased in size when viewed through glasses of the greatest magnifying power.

7. In order to ascertain the situations of these stars the more readily, they have been divided into *constellations;* and to distinguish their relative sizes, they have been classed into six magnitudes; namely, the largest are called stars of the first magnitude; those next in size, stars of the second magnitude; and so on to the sixth or last magnitude.

Obs. It must not be inferred that all the stars of each class appear of exactly the same magnitude, there being great latitude given in this respect; even those of the first magnitude appear almost all different in size and lustre. There are also other stars of intermediate magnitudes, which, as astronomers cannot refer them to any one particular class, they place between two classes. Procyon, for instance, which Ptolemy makes of the first magnitude, and Tycho of the second, Flamstead lays down as between the first and the second. Wherefore, instead of six magnitudes, we may say that

there are almost as many as there are stars, such considerable varieties being observable in their magnitude, colour, and brightness.

8. Those stars which are not arranged under any constellation, are called unformed stars; and those which appear for a season, are called periodical stars.

CHAPTER XV.

Of the Constellations.

1. A constellation is a cluster of stars forming a groupe, which astronomers have supposed to resemble the outlines of some animal, for the convenience of distinguishing them.

2. Stars are classed into 91 constellations or groupes, namely; 12 in the zodiac, 34 in the northern hemisphere, and 45 in the southern.

I. CONSTELLATIONS IN THE ZODIAC.

CONSTELLATIONS.	*Number of Stars.*	*Names of the principal Stars and their Magnitudes.*
1. Aries, *The Ram,*	66	Arietis, 2.
2. Taurus, *The Bull,*	141	Aldebaran, 1. The Pleiades. The Hyades.
3. Gemini, *The Twins,*	85	Castor and Pollux, 1. 2.
4. Cancer, *The Crab,*	83	
5. Leo, *The Lion,*	95	Regulus, or Lion's Heart, 1.
6. Virgo, *The Virgin,*	110	Spica Virginis, 1 Vindemiatrix, 2.
7. Libra, *The Balance,*	51	
8. Scorpio, *The Scorpion,*	44	Antares, 1.
9. Sagittarius, *The Archer,*	69	
10. Capricornus, *The Goat,*	51	
11. Aquarius, *The Water-bearer,*	108	Scheat, 3.
12. Pisces, *The Fishes,*	113	

II. THE NORTHERN CONSTELLATIONS.

CONSTELLATIONS.	Number of Stars.	Names of the principal Stars, and their Magnitudes.
1. Mons Mænalus, *The Mountain Mænalus*, . . .	11	
2. Serpens, *The Serpent*, .	64	
3. Serpentarius, *The Serpent-bearer*, ...	74	Ras Alhagus, 2.
4. *Taurus Poniatowski, *Bull of Poniatowski*, . . .	7	
5. *Scutum Sobieski, *Sobieski's Shield*, ...	8	
6. Aquila, *The Eagle*, Antinöus,	71	Altair, 1.
7. Equulus, *The little Horse*, .	10	
8. Leo Minor, *The little Lion*,	53	Deneb, 2.
9 Coma Berenices, *Berenice's hair*, . . .	43	
10 Asterion et Chara, vel, Canes Venatici, *The Grayhounds*, . .	25	
11. Bootes, ...	54	Arcturus, 1. Mirach, 3.
12. Corona Borealis, *The northern Crown*, ...	21	Alphacca, 2.
13. Hercules, . . Cerberus, *The three-headed Dog*, . .	113	Ras Algethi 3 in the head of Hercules.
14. Lyra, *The Harp*, . . .	21	Vega, 1.
15. Vulpecula et Anser, *The Fox and Goose*, . . .	35	
16 Sagitta, *The Arrow*, .	18	
17. Delphinus, *The Dolphin*, .	18	
18 Pegasus, *The Flying Horse*,	89	Markab, 2. Scheat, 2
19. Andromeda, . . .	66	Mirach, 2. Almaach, 2.
20. Triangulum, *The Triangle*,	11	
21. Triangulum Minus, *The Little Triangle*, . . .	5	
22. *Musca, *The Fly*, . .	6	

NORTHERN CONSTELLATIONS.

The following northern constellations do not set in the latitude of London.	*Number of Stars*	*Names of the principal Stars, and their Magnitudes.*
23. Ursa Minor, *The Little Bear*,	24	Pole Star, 2.
24. Ursa Major, *The Great Bear*,	87	Dubhe, 2. Alioth, 2. Benetnach, 2.
25. *Cor Caroli, *Charles's Heart*,	3	
26. Draco, *The Dragon*, .	80	Rastaben, 2
27. Cygnus, *The Swan*, . .	81	D eb Adige, 1.
28. Lacerta, *The Lizard*, .	16	
29. Cepheus, ...	35	Alderamin, 3.
30. Casiope, ...	55	Schedar, 3.
31. Perseus, . . Caput Medusæ, *The Head of Medusa*, . .	59	Algenib, 2. Algol, 2.
32. Cameleopardalus, *The Cameleopard*, . . .	58	
33 Auriga, *The Charioteer or Wagoner*, . . .	66	Capella, 1.
34. Lynx, *The Lynx*, .	44	

III. THE SOUTHERN CONSTELLATIONS.

CONSTELLATIONS.	*Number of Stars.*	*Names of the principal Stars, and their Magnitudes.*
1. Cetus, *The Whale*, . .	97	Menkar, 2
2. Eridanus, *The river Po*, .	84	Archerner, 1
3. Orion, ...	78	Bellatrix, 2. Betelgues, 1. Rigel, 1
4. Monoceros, *The Unicorn*, .	31	
5. Canis Minor, *The little Dog*,	14	Procyon, 1.
6. Hydra, ...	60	Cor Hydræ, 1.
7. Sextans, *The Sextant*, .	41	
8 *Microscopium, *The Microscope*, ...	10	
9. Piscis Notius vel Australis, *The southern Fish*, .	24	Fomalhaut, 1.
10. * Officina Sculptoria, *The Sculptor's Shop*, .	12	

SOUTHERN CONSTELLATIONS.	Number of Stars	Names of the principal Stars, and their Magnitudes.
11. *Fornax Chymica, *The Furnace,*	14	
12 Brandenburgium Sceptrum, *The Sceptre of Brandenburgh,* .	3	
13. Lepus, *The Hare,* . .	19	
14. *Columba Noachi, *Noah's Dove,*	10	
15 Canis Major, *The great Dog,*	31	Sirius, 1.
16 *Pyxis Nautica, *The Mariner's Compass,*	4	
17. *Machina Pneumatica, *The Air Pump,*	3	
18 Crater, *The Cup or Goblet,* .	31	Alkes, 3.
19 Corvus, *The Crow,* .	9	Algorab, 3.
The following southern constellations do not rise in the latitude of London.	*Number of Stars.*	*Names of the principal Stars, and their Magnitudes.*
20. Centaurus, *The Centaur,* .	35	
21. Lupus, *The Wolf,* . .	24	
22. *Norma, vel Quadra Euclidis, *Euclid's Square,* . .	12	
23. *Circinus, *The Compasses,* .	4	
24. *Triangulum Australe, *The southern Triangle,* . .	5	
25. *Crux, *The Cross,* . .	5	
26 *Musca Australis, vel Apis, *The southern Fly, or Bee,* . .	4	
27. *Chamæleon, *The Chameleon,*	10	
28. Ara, *The Altar,* . . .	9	
29 Telescopium, *The Telescope,*	9	
30 Corona Australis, *The southern Crown,*	12	
31 *Indus, *The Indian,* . .	12	
32 *Grus, *The Crane,* . .	13	
33. *Pavo, *The Peacock,* .	14	
34. *Apus, vel Avis Indica, *The Bird of Paradise,* . .	11	
35. *Octans Hadleianus, *Hadley's Octant,*	43	
36. *Phœnix, ...	13	
37. *Horologium, *The Clock,* .	12	
38. *Reticulus Rhomboidalis, *The Rhomboidal Net,* . .	10	
39. Hydrus, *The Water-snake,* .	10	
40. Toucan, *The American Goose,*	9	

SOUTHERN CONSTELLATIONS.		
The following southern constellations do not rise in the latitude of London.	*Number of Stars*	*Names of the principal Stars, and their Magnitudes*
41. Mons Mensæ, *The Table Mountain,*	30	
42. *Praxiteles, vel Cela Sculpturia, *The graver's or engraver's Tools,*	16	
43. *Equuleus Pictoreus, *The Painter's Easel,* . . .	8	
44. *Dorado, or Xiphias, *The Sword Fish,* . . .	6	
45. Argo Navis, *The ship Argo,* .	64	Canopus, 1
46. *Piscis Volans, *The Flying Fish,*	8	
47. *Robur Caroli, *Charles's Oak,*	12	

CHAPTER XVI.

Of Motion.

1. Motion is defined to be a continued and successive change of place. We are principally acquainted with two kinds of motions in the beings that surround us: one is that by which an entire body is transferred from one place to another, as the falling of a stone or the sailing of a ship; the other is a motion of parts of bodies among themselves, as the growth of animals and plants, the expansion or contraction of bodies, their composition and decomposition.

2. Heat causes the expansion, and cold the contraction of bodies; and, as the temperature is always varying, the particles of the most solid bodies are continually changing place.

3. In the consideration of motion, several things must be attended to, namely:

1. The force which impresses the motion;
2. The quantity of matter in the moving body;
3. The velocity of the motion;
4. The space passed over;
5. The time occupied in passing; and
6. The force with which it strikes an opposing body.

4. In a mechanical sense, every body, by its inertness, resists all change of place, and consequently remains in a state of rest, until impelled by some moving force; as the action of men and other animals, wind, water, gravity, the pressure of the atmosphere, and the elasticity of fluids and other bodies.

5. A body, when once put in motion, will for ever continue to move uniformly, unless resisted by some opposing power. Velocity of motion is estimated by the time employed in passing over a certain space, or by the space moved over in a certain time.

6. A body in motion must always tend to some particular point, in which case the motion will be in a straight line; or it may continually change the point of its direction, which will produce a curvilinear direction.

7. The motion of a body will be in the same direction in which the moving force acts.

8. If several powers differently applied or directed, act upon it at the same time, as it cannot obey them all, it will obey no one of them, but move in a direction somewhat between them: this is what is called the composition and resolution of motion.

9. Whenever we see a body moving in a curvilinear direction, we may be certain that it is acted upon by two forces at least; and when one

of these two forces ceases to act, the body will again move in a straight line: thus a stone in a sling is moved round by the hand, while it is pulled towards the centre of the circle which it describes by the string; but when the string is let go, the stone flies off in a tangent to the circle.

10. Every body moving in a circle, has a tendency to fly off from its centre, which tendency is called the *centrifugal force*:—this is opposed to the *centripetal force*, or that which, by drawing bodies towards the centre, makes them revolve in a curve. These two forces are together called *central forces*.

11. The centre of gravity of a body, is that point about which all the parts of a body do, in any situation, balance each other. Hence if a body be supported by this point, it will rest in any position in which it may be placed.

12. Whatever supports the centre of gravity of any body, bears the weight of the whole body; and while this is supported, it cannot fall.—We may therefore consider the whole weight of any body as centred in this point.

13. The common centre of gravity of any two or more bodies, is the point about which they would equiponderate or rest in any position.

14. Motion, in astronomy, may be divided into *real* and *apparent*. ***Real motion*** is the actual movement of any body; as the revolution of the earth *Apparent motion* is when a body *appears* to move, when it is actually at rest; as the *apparent* motion of the sun and stars, produced by the *real* motion of the earth.

CHAPTER XVII.

Of Eclipses.

1. An eclipse is an obstruction of the sun's rays, caused by the interposition of the dark body of a planet.

2. Every planet, being illuminated by the sun, casts a shadow in a direction opposite to the sun; consequently a planet passing through this shadow, is darkened by it, the sun's rays being obscured by the intervening planet.

3. There are commonly considered two kinds of eclipses, namely, that of the sun, and that of a planet.

4. An eclipse of the sun is the obscuration of his light, occasioned by the interposition of the moon between the earth and the rays of the sun, or by the earth's passing through the shadow of the moon, she being near one of her nodes.

5. Eclipses of the sun happen only when the moon is in conjunction with the sun, as at the time of new moon.

6. A partial eclipse of the sun is when the penumbra or imperfect shadow of the moon, falls upon that part of the earth's surface where the partial eclipse is seen.

7. A total eclipse of the sun is when the moon's shadow falls upon that part of the earth where the eclipse is observed.

8. An eclipse of the sun will be central at new moon, when she is in one of her nodes.

9. An annular eclipse of the sun is when a ring of the sun appears around the edges of the moon: and a *central* eclipse of the sun will always be an

annular one, if the distance of the moon from the earth be greater than its mean distance.

10. An eclipse of the moon is the obscuration of her light, occasioned by the interposition of the earth between the sun and moon; which can only happen at full moon, or when the moon is in opposition to the sun.

11. The shadow of the earth is a *cone*, the base of which is on the surface of the earth, and the moon is eclipsed by this cone or shadow.—This is evident from the sun's being larger than the earth.

12. A partial eclipse of the moon is when a part of the moon's disk is within the shadow of the earth; total, when all her disk is covered by the shadow; and central, when the shadow of the earth falls upon the centre of the moon's disk.

13. Were the orbit of the moon, and that of the earth, in the same plane, there would be an eclipse of the moon at every full moon, and an eclipse of the sun at every new moon: but the orbit of the moon makes an angle with the orbit of the earth, of about $5\frac{1}{4}$ degrees. The places at which these lines intersect are called the moon's *nodes*.

14. Eclipses of the satellites of Jupiter frequently happen, and are of the utmost importance in calculating the longitudes of places, because their immersion and emersion take place at the same instant of time, on all parts of the earth's surface.

A TABLE OF ECLIPSES.

Years		Months and Days.	Time.	Years		Months and Days.	Time.
1825	☾ P	June 1	0½ M	1840	☾ P	Feb 17	2 A
——	☉	June 16	0½ A		☉	March 4	4 M
——	☾ P	Nov. 25	4½ A	——	☾ P	Aug. 13	7½ M
1826	☾ T	May 21	3½ A	1841	☾ [illegible]	Feb. 6	2½ M
——	☾ T	Nov. 14	4½ A	——	☉	Feb. 21	11 M
——	☉	Nov. 29	11½ M	——	☉	July 18	2 A
1827	☾ P	Nov. 3	5 A	——	☾	Aug. 2	10 M
1828	☉	April 14	9¾ M	1842	☾ P	Jan 26	6 A
——	☉	Oct. 9	0½ M	——	☉	July 8	7 M
1829	☾ P	March 20	2 A	——	☾ P	July 22	11 M
——	☾ P	Sept. 13	7 M	1843	☾ P	June 12	8 M
——	☉	Sept. 28	2½ M	——	☾ P	Dec 7	0½ M
1830	☉	Feb. 23	5 M	——	☉	Dec. 21	5½ M
——	☾ T	March 9	2 A	1844	☾ [illegible]	May 31	11¼ A
——	☾ T	Sept. 2	11 A	——	☾ T	Nov. 25	0¼ M
1831	☾ P	Feb. 26	5 A	1845	☉	May 6	10½ M
——	☾ P	Aug. 23	10½ M	——	☾ [illegible]	May 21	4½ A
1832	☉	July 27	2½ A	——	☾ P	Nov. 14	1 M
1833	☾ P	Jan. 6	8 M	1846	☉	April 25	5½ A
——	☾ P	July 2	1 M	——	☉	Oct. 20	8½ M
——	☉	July 17	7 M	1847	☾ P	March 31	9½ A
——	☾ [illegible]	Dec. 26	10 A	——	☉	Sept. 24	3 A
1834	☾ T	June 21	8½ M	——	☉	Oct. 9	9½ M
——	☾ P	Dec. 16	5¼ M	1848	☾ T	March 19	9½ A
1835	☉	May 27	1½ A	——	☾ [illegible]	Sept. 13	6½ M
——	☾ P	June 10	11 A	——	☉	Sept. 27	10 M
——	☉	Nov. 20	11 M	1849	☉	Feb. 23	1½ M
1836	☾ P	May 1	8½ M	——	☾ P	March 9	1 M
——	☉	May 15	2½ A	——	☾ P	Sept. 2	5½ A
——	☾ P	Oct. 24	1¾ A	1850	☉	Feb. 12	6½ M
1837	☾ T	April 20	9 A	——	☉	Aug. 7	10 A
——	☉	May 4	7½ A	1851	☾ P	Jan. 17	5 A
——	☾ [illegible]	Oct. 13	11½ A	——	☾ P	July 13	7½ M
1838	☾ P	April 10	2¼ M	——	☉	July 28	2½ A
——	☾ P	Oct. 3	3 A	1852	☾ T	Jan. 7	6½ M
1839	☉	March 15	2½ A	——	☾ T	July 1	3¾ A
——	☉	Sept. 7	10½ A	——	☉	Dec 11	4 M

CHAPTER XVIII.

Of Tides.

1. Tide is defined to be a periodical motion, or flux and reflux, of the waters in seas and rivers, caused by the attractive action of the sun and moon upon the ocean.

2. The waters ebb and flow twice in every lunar day, or periodical return of the moon to the same meridian, making nearly two ebb and two flood tides every day.

3. The ocean covers more than half of the earth's surface; and this large body of water is continually in motion, ebbing and flowing alternately.

4. The water flows for the space of six hours, and apparently rests for a few minutes, when it is called high water. It then subsides, flowing back six hours, when the rivers resume their natural course, and the tide is said to be at low water-mark.

5. The time of high water is not always the same, but is about three quarters of an hour later every day, for the space of about 30 days, when it begins again as before.*

Obs. We will suppose, at a certain place it is high-water at 3 o'clock in the afternoon on the day of new moon; the next day it will be high water 3 quarters of an hour after three; and the next succeeding day, about ½ past 4; and so on to the next new moon, when it will again be high water at 3.—This answers to the motion of the moon, for the moon rises every day about 45 minutes later than the day preceding; or, it is 24 hours 45 minutes from the time of the moon's appearing on

* This retardation actually varies from 24 hours 30 minutes to 25 hours 30 minutes.

any meridian to the time at which it appears on the same meridian again.

According to the Newtonian principles of attraction, these phænomena are thus explained :—The waters on the side of the earth next to the moon are more attracted than the central parts by the moon ; and these again more than the waters on the opposite.—Therefore the distance between the earth's centre, and the waters on its surface under the moon and opposite to it, will be increased To explain this more particularly, though the diameter of the earth bears a considerable proportion to its distance from the moon, yet this diameter is nothing, compared with the earth's distance from the sun ; consequently the difference of the sun's attraction on the sides of the earth next to him, will be far less than the difference of the moon's attraction on the sides opposite to her ; therefore the moon must raise the waters higher than they could be raised by the sun.

6. Sir Isaac Newton determined the influence of the sun on the earth to be three times less than that of the moon.

7. The tides, being the joint production of the sun and moon, are properly two, *solar* and *lunar*, whose effects are joint or opposite, according to the situation of the bodies by which they are effected.

8. When the sun and moon act together, as at new and full moon, the flux and reflux become considerable, and are called *spring tides.* But when one tends to elevate, and the other to depress the waters, as at the moon's first and third quarters, the flux and reflux will be diminished : these are called *neap tides.*

9. The sun's being farther from our hemisphere in March and September, than in February and October, is the reason that the greatest tides happen a little before the vernal, and a little after the autumnal equinox.

10. When the moon is in the equator, the tides

are equally high in both parts of the lunar day, which is 24 hours 48 minutes; but as she declines toward either pole, the tides are alternately higher or lower, in northern and southern latitudes.

11. The tides are so retarded in their passage through channels, and so affected by capes and headlands, as to happen variously at different places.

12. The tide raised in the German ocean, when the moon is 3 hours past meridian, takes 3 hours to arrive at London bridge.

13. Lakes have no tides, because every part is attracted alike.

14. The Mediterranean and Baltic seas have but small elevations, on account of the narrowness of the inlets by which they communicate with the ocean.

15. The tides often rise at the bay of Fundy, and the gulf of St. Lawrence, to the astonishing height of 50 or 60 feet.

CHAPTER XIX.

Of Atmosphere.

1. Atmosphere is an elastic fluid surrounding the earth. It is necessary not only to the comfort and convenience of life, but to the support of life itself, and to the constitution of matter in general.

2. The atmosphere is perceptible to the height of about 45 miles above the surface of the earth; and consists of nitrogen, oxygen, and carbonic acid gas.

3. The average weight or pressure of the atmosphere upon every foot of the earth's surface, is 2100 pounds. As we ascend it becomes more

rarefied, and less dense; consequently the pressure is not so great upon high ground, as it is upon low.

4. As the earth, and the ambient parts of the atmosphere, revolve together uniformly about the common axis, the different parts of both have a centrifugal force, whose tendency is more considerable, and a centripetal force, whose tendency is less considerable, according as the parts are more or less remote from the axis; hence the figure of the atmosphere is that of an oblate spheroid, since the parts corresponding to the equator are farther from the axis than those at the poles.

Obs. The pressure of the atmosphere sustains a column of quicksilver, in the tube of a barometer, of about 30 inches in height; hence the whole weight is equal to a column of quicksilver 30 inches in height, and of equal base; and as a cubical inch of quicksilver weighs nearly ½lb. avoirdupois, every square inch of surface sustains 15 lbs. of atmosphere. From this it is computed, that the pressure of this fluid on the surface of the earth, is equal to that of a globe of lead 60 miles in diameter; consequently the pressure upon the human body, cannot be less than 32400lbs. which would crush it to atoms were it not filled with some elastic fluid, which counterbalances this weight.

Were the atmosphere not elastic, but every where equable, its height would be determined from its density, and the column of mercury it would counterbalance in the tube of a barometer. The height of the atmosphere would then be 11040 times thirty inches, or about 54 miles; but the air being very elastic, and the more it is compressed, the less space it occupies, it follows that in the upper regions, as it ascends it must become more rarified, till it extends to an infinite height. At the height of 3½ miles, the density of the atmosphere is twice as much rarefied as at the earth's surface; and at 7 miles elevation, four times as much; and so on in a geometrical progression. From this calculation it might be proved, that a cubic inch of the air we breathe, would be so rarefied at the

height of 500 miles, as to fill a sphere, equal in diameter to the orbit of Saturn: this however may be considered almost an idle speculation.

CHAPTER XX.

Of Wind.

1. Wind is a body of the atmosphere put in motion. We may attribute the general cause of wind, to heat and electricity.

2. Currents of winds thus produced, may be *permanent* and *general*, extending over a large portion of the globe, *periodical*, as in the Indian ocean, or *variable*, as in temperate climates.

3. *Permanent* and *general winds* blow nearly in the same direction. In the Atlantic and Pacific oceans they generally follow the course of the sun, to the distance of about 28° on either side of the equator. By navigators they are generally called *trade winds.*

4. *Periodical winds*, or *monsoons*, blow in one direction for about 6 months, then change and blow in the opposite direction 6 months; namely, from April to September they blow southward, the whole length of the Indian ocean, between 28° north and 28° south latitude, and from October to March, they blow northward.

5. *Variable winds* are such as blow in every possible direction.

6. *Hermattan* are singular winds, blowing periodically, from the interior of Africa towards the Atlantic.

7. *Sirocco* or *Siroc* blow in Italy, and resemble, in some measure, the Hermattan, but are very hot and unhealthy.

8. The *Samiël* blow in the deserts of Bagdad, and are of all others the most to be dreaded in their effects.

9. The *Simoom* blow in the sandy deserts of Africa.

10. The following table shows the velocity and pressure of the winds, according to their different appellations.

Velocity of the Wind.		*Perpendicular force on the square foot, in pounds avoirdupois.*	*Common appellations of the Winds.*
Miles in one hour.	*Feet in one second.*		
1	1.47	.005	Hardly perceptible.
2	2.93	.020	Just perceptible.
3	4.40	.044	
4	5.87	.079	Gentle pleasant wind.
5	7.73	.123	
10	14.67	.492	Pleasant brisk gale.
15	22.00	1.107	
20	29.34	1.968	Very brisk.
25	36.67	3.075	
30	44.01	4.429	High winds.
35	51.34	6.027	
40	58.68	7.873	Very high.
45	66.01	9 963	
50	73.35	12 300	A storm or tempest.
60	88.02	17.715	A great storm.
80	117.36	31.490	A hurricane.
100	146.70	49.200	A hurricane that tears up trees, and carries buildings, &c., before it.

CHAPTER XXI.

Of Climates.

1. A climate, reckoning from the equator to either of the polar circles, is a space upon the surface of the earth, included between two such parallels of latitude, that the longest day in the one, exceeds the longest of the other, by half an hour; but from the polar circles to the poles, climates are measured by the increase of a month.

2. There are twenty-four climates between the equator and each of the polar circles, and six from each polar circle to its respective pole.

Obs. We must not infer from the definition above, that the temperature is always the same in the same climate—quite to the contrary; for elevated situations, woods, morasses, lakes, sandy deserts, &c. have much effect on the atmosphere. Thus, some of the mountains in Asia and South America, although in the torrid zone, are at their summits perpetually covered with snow, which cools the air for some distance around.

I. Climates between the Equator and the Polar Circles.

Climate.	*Ends in latitude*	*Where the longest day is*	*Breadth of the Climates.*
	° ′	H. M.	° ′
I.	8 34	12 30	8 34
II.	16 44	13	8 10
III.	24 12	13 30	7 28
IV.	30 48	14	6 39
V.	36 31	14 30	5 43

Climates, &c., continued.

Climates.	Ends in latitude		Where the longest day is		Breadth of the Climates.	
	°	′	H	M.	°	′
VI.	41	24	15		4	53
VII.	45	32	15	30	4	8
VIII.	49	2	16		3	30
IX.	51	59	16	30	2	57
X.	54	30	17		2	1
XI.	56	38	17	30	2	38
XII.	58	27	18		1	49
XIII.	59	59	18	30	1	32
XIV.	61	18	19		1	9
XV.	62	26	19	30	1	18
XVI.	63	22	20			56
XVII.	64	10	20	30		48
XVIII.	64	50	21			40
XIX.	65	22	21	30		32
XX.	65	48	22			26
XXI.	66	25	22	30		17
XXII.	66	21	3			16
XXIII.	66	29	23	30		8
XXIV.	66	32	24			3

II. CLIMATES between the POLAR CIRCLES and the POLES.

Climates.	Ends in latitude		Where the longest day is		Breadth of the Climates	
	°	′	Days.	Month.	°	′
XXV.	67	18	30 or	1		46
XXVI.	69	33	60	2	2	15
XXVII.	73	5	90	3	3	32
XXVIII.	77	40	120	4	4	35
XXIX.	82	59	150	5	5	19
XXX.	90		180	6	7	1

CHAPTER XXII.

Of the Aurora Borealis, Milky-way, and Zodiacal Lights.

1. Aurora Borealis, or the northern light, is a meteor, which appears in the northern part of the heavens, on cold frosty evenings in the winter season.

2. It generally appears in streaks of yellow and reddish colour, the coruscations rising from the horizon, in the form of pyramids, and shooting upwards toward the zenith.—The flashes sometimes have the appearance of contending armies in the heavens.

3. The Aurora Borealis is attributed to the effect of electricity in the atmosphere. It is not unfrequently seen in this country, but with much less brilliancy than in the more northern regions.

4. This light, in the northern parts of Europe, America, and Asia, is frequently equal to the light of the full moon, and supplies, in a great measure, the absence of the sun. The streaks are supposed by Euler to extend several thousand miles.

Obs. "Dr. T. L. Thieneman, who spent the winter of 1820 and 1821 in Iceland, made numerous observations on the polar lights. He states the following as some of the general results of his observations: 1. The polar lights are situated in the lightest and highest clouds of our atmosphere. 2. They are not confined to the winter season or to the night, but present in favourable circumstances at all times, but are only distinctly visible during the absence of the solar rays. 3. The polar lights have no determinate connexion with the earth. 4. He never heard any noise proceed from them. 5. Their common form, in Iceland, is the arched, and in a direc-

tion from N. E. and W. S W. 6. Their motions are various, but always within the limits of the clouds which contain them."

5. The Galaxy, or *Milky-way*, is a bright, luminous circle of some breadth in the heavens, and distinguished by its superior brilliancy.

6. It is composed of a vast number of stars, too minute to be seen by the naked eye, but with a good telescope, they may be observed in almost countless numbers. 50,000 were enumerated by Dr. Herschel in a small part, only 15 degrees in length and 2 in breadth.

7. Zodiacal Light is a brightness sometimes observed in the zodiac, resembling that of the galaxy. It appears only at certain seasons, namely, towards the end of winter, and in spring after sunset; or before sunrise in autumn and the beginning of winter. Its form is that of a pyramid lying lengthwise, with its axis along the zodiac, its base being placed obliquely with respect to the horizon.

CHAPTER XXIII.

Of Time.

1. Time is the measure of duration, and is divided into years, months, days, hours, minutes, and seconds.

2. A year is the space of time occupied by the earth, in performing its revolution around the sun, through the 12 signs of the zodiac. A year is of two kinds, *tropical* and *sidereal.*

3. A *tropical* or *natural year* is the time which the earth takes to pass through the fixed zodiac,

which, as has been before observed, is 365 days 5 hours 48 minutes $45\frac{1}{2}$ seconds.

4. A *sidereal* or *astral year* is the time that the sun apparently occupies in passing from a fixed star to its arrival at the same star again; and is 365 days 5 hours 9 minutes 17 seconds in length.

5. The *common* or *civil year* is commonly reckoned at 365 days; but the true tropical year consists of about $365\frac{1}{4}$ days; hence if the civil year be made to consist of 365 days, every fourth year must be 366 days.

6. A common civil year is divided into twelve months, of which one has 28 days; seven have 31; and four 30 days each. The one that has 28 days, has 29 every *fourth* year.

7. A *day* is that portion of time which the earth takes to complete an entire rotation on its axis; and is divided into *natural*, *civil*, *artificial*, *astronomical*, and *sidereal*.

8. A *natural day* is the time the earth occupies to revolve once on its axis.

9. A *civil day* is twice 12 hours. In England, and in the United States, it is reckoned from midnight to midnight.

OBS. The ancient Athenians, the Jews, &c. began their day at sun-setting, which custom is followed by the modern Austrians, Bohemians, Silesians, Italians, and Chinese. The ancient Babylonians, Persians, Syrians, and most of the eastern nations, began their day at sun-rising. The Egyptians and Romans began their day at midnight, and are followed by the English, the Americans, French, Germans, Spanish, Dutch, and Portuguese. The Arabians begin their day at noon like the modern atronomers.

10. An *artificial day* is the interval between the rising and the setting of the sun.

11. An *astronomical day* is the time whcih

elapses from the sun's appearing on a meridian to the time of his appearing on the same meridian again. It is reckoned from noon to noon.

12. A *sidereal day* is the time which the earth requires to perform a complete rotation on its axis from a fixed star to the same star again.

13 An hour is the 24th part of a day, a minute the 60th part of an hour, and a second the 60th part of a minute.

14. *Mean time* is that shown by a well-regulated clock, dividing the day into 24 equal parts.

15. *Apparent time* is that shown by a correct sundial.

16. *Equation of time* is the difference between mean and apparent time; or the time shown by a clock and that by a sundial.

Obs. A true solar day is subject to a continual variation, on account of the obliquity of the ecliptic, and the unequal motion of the earth in its orbit; the duration thereof sometimes exceeds, and at others falls short, of 24 hours; and the variation is greatest about the first of November, when the solar day is 16 min. 15. sec. less than 24 hours, as shown by a clock.

There are, in the course of the year, as many mean solar days as there are true ones, the clock being as much faster than the sundial on some days of the year, as the sundial is faster than the clock on others. Thus the clock is faster than the sundial from the 24th of December to the 15th of April, and from the 16th of June to the 31st of August; but from the 15th of April to the 16th of June, and from the 31st of August to the 24th of December, the sundial is faster than the clock.

When the clock is faster than the sundial, the true solar day exceeds 24 hours; but when the clock is slower than the sundial, the true solar day is less than 24 hours. When the clock and sundial agree, which happens about the 15th of April, 16th of June, 31st of August, and 24th of December, the true solar day is exactly 24 hours.

CHAPTER XXIV.

Of the Globes.

1. Artificial globes are of two kinds, *terrestrial* and *celestial.*

2. The *terrestrial globe* is a spherical body intended to represent the true figure of the earth, the relative situations of different countries, seas, lakes, and rivers; and to illustrate the phænomena arising from its diurnal motion, which is from west to east.

3. The *celestial globe* is intended to represent the face of the heavens; the places of the fixed stars, as situated in their several constellations; and the apparent diurnal motion of the sun and stars, as they would appear to a spectator in the centre of the globe. The diurnal motion of this globe is from east to west.

4. The globes commonly used are composed of plaster, on which the maps, or descriptions, are pasted. When finished, they are hung in a brass meridian, with an hour circle, and a quadrant of altitude, and fitted into a wooden horizon.

5. The axis of the earth is an imaginary line passing through the centre of it, upon which it is supposed to turn, and about which all the heavenly bodies appear to perform a diurnal revolution. This line is represented by the wire which passes through the middle of the globe, from north to south.

6. The poles of the earth are the two extremities of the axis, where it is supposed to cut the surface of the earth. One of these extremities is

called the *north* or *arctic pole*, and the other, the *south* or *antarctic pole.*

7. Ten principal circles of the sphere, are marked on the globes, 6 great, and 4 small ones. The great circles divide the globe into equal parts; the small circles, into unequal parts.

8. The *great circles* are, the horizon, meridian, equator, ecliptic, and the two colures.

9. The *small circles* are the two tropics and the two polar circles. The tropic of Cancer is drawn 23° 28′ north latitude: the tropic of Capricorn is drawn 23° 28′ south latitude. The arctic circle is 23° 28′ south of the north pole; and the antarctic circle 23° 28′ north of the south pole. All of these circles are parallel to the equator.

10. Of the circles of the sphere, some are fixed, always keeping the same position; others moveable, according to the position of the observer.

11. The *horizon* is the broad wooden circle surrounding the globe, and dividing it into two equal parts, called upper and lower hemispheres.

12. On the face, or flat side of the horizon are described 8 concentric circles. The first circle is marked *amplitude;* the second, *azimuth:* on these are reckoned the amplitude and azimuth of the celestial bodies. The third contains the 32 points of the compass. The fourth circle contains the 12 signs of the zodiac. The fifth contains the degrees of the signs, each sign comprehending 30 degrees. The sixth contains the days of the month, corresponding to each degree. The seventh circle contains the equation of time. The eighth circle contains the 12 calendar months of the year.

13. The *brass meridian* is a ring of brass divided into 360 degrees, each quadrant or quarter

containing 90 degrees. This circle divides the globe into two equal parts, called the eastern and western hemispheres.

14. The *equator** is an imaginary line extending around the centre of the globe from east to west, equidistant from the poles, and dividing it into northern and southern hemispheres.

15. The *longitude* of places is marked on the equator eastward and westward from the meridian of London. *Latitude* is reckoned from the equator north and south.

16. The *ecliptic* is an imaginary line drawn through the middle of the zodiac, in which the earth makes its annual revolution round the sun; or, it is the apparent path of the sun among the fixed stars.

17. The ecliptic forms an angle of 23° 28′ with the equator; the points of intersection are called the equinoctial points. On the ecliptic are marked the 12 signs of the zodiac.

18. The *colures* are two great circles, supposed to intersect each other at right angles, in the poles of the world, and to pass through the solstitial and equinoctial points of the ecliptic. The equinoctial points are Aries and Libra; and the solstitial points, Cancer and Capricorn. These divisions of the ecliptic mark the seasons of the year.

19. The *quadrant of altitude* is a thin pliable plate of brass, divided into 90 degrees, answering exactly to a quadrant of the meridian, and has a notch, nut, and screw, to fix it to the brazen meridian, in the zenith of any place, where it turns round a pivot, and supplies the place of vertical circles.

20. The *hour circle* is a flat ring of brass, divid-

* The equator is called the equinoctial on the celestial globe.

ed into 24 equal parts, or hour distances; and on the pole of the globe is fixed an index that turns with it, and points out the hours upon the hour circle.*

21. *Parallels of latitude* are small circles drawn on the terrestrial globe every ten degrees parallel to the equator.

22. Meridians of longitude are semicircular lines extending from one pole to the other, and crossing the equator at right angles. The first meridian, or that from which longitude is reckoned, is the meridian of the royal observatory at Greenwich, near London.

23. The *zodiac*, on the celestial globe, extends 8 degrees on each side of the ecliptic, forming a girdle, or belt, within which space all the planets perform their annual revolution, except Ceres and Pallas.

24. The sun apparently moves through the zodiac at the rate of nearly a degree every day. The sun in his apparent movement through the ecliptic enters the signs as follow:

Spring Signs.	*Summer Signs.*
♈ Aries, 21st of March.	♋ Cancer, 21st of June.
♉ Taurus, 19th of April.	♌ Leo, 22d of July.
♊ Gemini, 20th of May.	♍ Virgo, 22d of August.

The signs above are called northern signs, being north of the equator; consequently when the sun is in any of these signs, his declination is north.

Autumnal Signs.	*Winter Signs.*
♎ Libra, 23d of September.	♑ Capricornus, 21st of Dec.
♏ Scorpio, 23d of October.	♒ Aquarius, 20th of Jan.
♐ Sagittarius, 22d of Nov.	♓ Pisces, 19th of Feb.

* Some modern globes have a moveable hour circle, and the time on these is shown by the cross meridian.

The autumnal and the winter signs are southern signs: when the sun is in any of these signs, his declination is south. The declination of the sun can never exceed 23° 28′; that of a star 90°; and that of a planet 30° north or south.

25. The *analemma* is a projection of a sphere on a plane of the meridian, made by straight lines, which are supposed to be at an infinite distance in the east or the west point of the horizon.

ASTRONOMICAL

AND

Geographical Problems

PERFORMED BY THE GLOBES.

Problems performed by the Terrestrial Globe.

PROBLEM I.

To find the latitude of any place.

Rule. Bring the given place to the brass meridian, and the degree over it, counting from the equator, is the latitude required.

1. Required the latitude of Washington,

New-York,	Baltimore,
St. Petersburg,	Stockholm,
Philadelphia,	Ispahan,
Edinburgh,	Amsterdam,
Constantinople,	Cape Horn,
London,	Cape of Good Hope,
Boston,	Prague,
Lisbon,	Liverpool,
Naples,	Halifax.

Obs. The latitude of places cannot be determined on small globes nearer than about a quarter of a degree; but on large globes each degree on the brass meridian being divided into three equal parts, the latitude may be determined as near as 10 minutes.

PROBLEM II.

To find the longitude of any given place.

RULE. Bring the place to the graduated side of the brass meridian, and the degree under it on the equator, counting from the meridian of London, is the longitude required.

1. Required the longitude of Washington,

New-Orleans,	Moscow,
Boston,	Warsaw,
Dublin,	Madrid,
Bengal,	Madras,
Norfolk,	Lisbon,
Tripoli,	Quito,
Vienna,	Cairo,
Athens,	Aleppo,
Batavia,	Portland.

OBS. On Bardin's Globes there are two rows of figures above the equator, but the lower is always used in reckoning longitude. Adam's globes have also two rows of figures above the equator, the lower line is used when the place lies on the left of the meridian of London; and the upper line is used when the place lies on the right of the meridian of London.

PROBLEM III.

To find all places having the same latitude as any given place.

RULE. Find the latitude of the given place; turn the globe on its axis, and all those places

passing under the observed latitude, are the places required.

1. Required those places having nearly the same latitude as Philadelphia.

Ans. Madrid, Constantinople, Naples, &c.

2. Required those places having nearly the same latitude as New Orleans.

3. Required those places having nearly the same latitude as Edinburgh.

4. Required those places having nearly the same latitude as Port Royal in Jamaica.

5. Required those people having the same length of day and night as the inhabitants of New-York.

6. Required those people having the same length of day and night, as the inhabitants of London.

7. Required those places having the same latitude as Calcutta.

8. Required those places having the same latitude as Quito.

9. Required those places having the latitude of Washington.

10. Required those people having the same length of day and night, as the inhabitants of Paris.

OBS.—All places in the same latitude have the same length of day and night.

PROBLEM IV.

To find all places having the same longitude as any given place.

RULE. Bring the given place to the brass me-

ridian, and all the places under the same edge have the same longitude.

1. What places have the same longitude as Dantzic?

Ans. The cape of Good Hope, Presburg, Stockholm, &c.

2. Required those places having the same longitude as Quebec.

3. Required those places having the same longitude as London.

4. Required those people having noon at the same time as the inhabitants of New-York.

5. Required those places having midnight at the same time as at Washington.

6. Required those people having sunrise at the same time as the inhabitants of St. Louis.

7. Required those people having sunset at the same time as the inhabitants of Archangel.

8. Required those places having sunset when it is sunrise at Vienna.

9. When it is noon at Alexandria, at what places is it midnight?

10. Required those places having the same longitude as the Pelew Islands, Pekin, London, Boston, and Portland.

Obs. Places on the meridian of London, and its opposite meridian, marked 180°, may be said to have no longitude, i. e. they are in neither east nor west longitude. All places on the same meridian from 66° 28′ north, to 66° 28′ south latitude, have noon, midnight, sunrise, and sunset at the same time.

PROBLEM V.

To find any place having the latitude and longitude given.

RULE. Bring the given degree of longitude to the brass meridian, and under the given degree of latitude, will be the place required.

1. Required the place having 151° east longitude, and 34° south latitude.

Ans. Botany Bay.

2. Required the place situated in about 6° west longitude, and 16° south latitude.

Ans. St. Helena.

3. Required those places having the following latitudes and longitudes.

Latitude.	Longitude.	Latitude.	Longitude.
34° 29′ S.	18° 23′ E.	32° 25′ N.	55° 50′ E.
64 34 N.	38 58 E.	34 35 S.	58 31 W.
31 13 N.	29 55 E.	3 49 S.	102 10 E.
52 22 N.	4 51 E.	32 38 N.	17 6 W.
55. 58 N.	3 12 W.	36 5 N.	5 22 W.
48 12 N.	16 16 E.	22 54 S.	42 44 W.
50 6 N.	5 54 W.	8 32 N.	81 11 E.

PROBLEM VI.

To find the latitude and longitude of any given place.

RULE. Bring the given place to the brass meridian; the degree over it will be the latitude, and

the degree on the equator, cut by the meridian, will be the longitude required.

1. Required the latitude and longitude of

Liverpool,	Constantinople,
Leghorn,	New-York,
Gibraltar,	Washington,
Copenhagen,	Havanna,
Canton,	Savannah,
Aberdeen,	Madrid,
Botany Bay	Stockholm,
St. Helena,	Dublin,
Alexandria,	Lisbon,
Bombay,	Oporto,
Cayenne,	Rome,
Ephesus,	Elba.

Obs. The problem above is only a combination of the first and the second.

As all latitudes are reckoned from the equator, and all longitudes from the first meridian, it is evident, that the point of the equator cut by the first meridian, has neither latitude nor longitude. The greatest latitude is 90 degrees, because no place is more than 90° from the equator. The greatest longitude is 180 degrees, because no place is more than 180 degrees from the first meridian.

PROBLEM VII.

To find the difference of latitude between any two given places.

Rule. Find the latitudes of both places; if the latitudes be both north, or both south, subtract the less from the greater, and the remainder will be the difference of latitude; but if one of the latitudes be north, and the other south, add them together,

and their sum will be the difference of latitude required: or, count the number of degrees on the brass meridian between the observed latitudes of the two places.

1. Required the difference of latitude between Buenos Ayres and Madrid.

Ans. 75 degrees.

2. Required the difference of latitude between

Quebec and New Orleans,
Washington and Quebec,
Mexico and Washington,
New-York and London,
Boston and Liverpool,
Baltimore and Edinburgh,
Lima and St. Petersburg,
Paris and Calcutta,
Archangel and Moscow,
Constantinople and Algiers,
Rome and Aberdeen,
Vienna and Alexandria,
Cape Horn and Cape of Good Hope,
Copenhagen and Stockholm,
Oporto and Londonderry.

PROBLEM VIII.

To find the difference of longitude between any two given places.

RULE. Find the longitudes of both places, if the longitude of one be east, and the other west, add them together, and their sum will be the difference of longitude;* but if both be east, or both

* When the sum of the two longitudes exceeds 180°, subtract it from 360°, and the remainder will be the difference of longitude.

west, subtract the less from the greater, and the remainder will be the difference of longitude required.

1. Required the difference of longitude between Owhyhee and Botany Bay.

Ans. 52¾ degrees.

2. Required the difference of longitude between
Mexico and Washington,
London and New-York,
Constantinople and London,
Mount Hecla and Mount Etna,
Batavia and Bombay,
Gibraltar and Behring's Straits,
Paris and Glasgow,
Cordova and Londonderry,
Portland and St. Louis,
St. Louis and the mouth of Columbia river,
St. Helena and Elba,
Cape, Ortegral and Cape Verd,
Calcutta and Delhi,
Cairo and Canton.

PROBLEM IX.

To find the distance between any two given places.

RULE. Bring one of the given places to the brass meridian, over which fix the quadrant of altitude; then extend it over the other place, and the number of degrees on the quadrant contained between them is the distance in degrees. Or, extend the quadrant of altitude over both places, and count the number of degrees contained between them. Multiply the number of degrees by 69½, and the product will be the number of English

miles; multiply the degrees by 60, and the product will be geographical miles.

1. Required the distance between New-York and London,

Boston and New-Orleans,
St. Petersburg and Archangel,
Cape St. Roque and Cape Blanco,
Cape Horn and Cape de la Vela,
Cape Maize and Cape Bonavista,
Aleppo and Calcutta,
Tripoli and Algiers,
Jerusalem and Ispahan,
Bagdad and Smyrna,
Copenhagen and Cadiz,
Rome and Astrachan,
Glasgow and Quebec,
Lisbon and Naples,
Halifax and St. Augustine.

2. Required the distance between the northern and the southern, the eastern and the western extremities of Europe, Asia, Africa, America, and New-Holland.

Obs. 1. If the two places be situated in the same latitude, their difference of longitude, multiplied by the number of miles in a degree of the given latitude, will be the distance between them in miles.

2. If both places be in the same longitude, their difference of latitude, multiplied by the number of miles in a degree, will be the distance between them in miles.

PROBLEM X.

To find the bearing of one place from another.

Rule. Bring one of the places to the brass meridian, screw the quadrant of altitude over it;

then extend the quadrant over the other place, and the point of its direction, as seen on the horizon, will be the bearing required.

1. What direction must a ship sail on a voyage from Charleston to Dublin.

2. Required the bearing between New-York and the following places.

Savannah,	Brussels,
St. Louis,	Athens,
Philadelphia,	Stockholm,
Montreal,	Bath,
Boston,	Belfast,
Augusta,	Lima,
Pensacola,,	Buenos Ayres.
Vienna,	Cordova,
Moscow,	Mexico,
Paris,	Utica.

PROBLEM XI.

A particular place, and the hour of the day, given, to find all the places where it is then noon, or any other given hour.

Rule. Bring the given place to the brass meridian, set the index of the hour circle at the given hour; then turn the globe on its axis until the index points to the upper 12; and to all places lying under the brass meridian, it is then noon.

1. When it is 10 o'clock in the morning at New-York, at what places is it noon?

Ans. Cape Farewell, &c.

2. When it is 8 o'clock in the evening at London, at what places is it 10 in the morning?

3. When it is 4 o'clock in the morning at Canton, where is it 4 in the evening?

4. At Vienna when it is 7 in the morning, where is it noon?

5. At Edinburgh when it is noon, where is it 10 in the evening?

6. At Washington when it is 6 o'clock in the evening, where is it noon?

7. Where is it midnight, when it is noon at Baltimore?

8. When it is noon at Charleston, where is it midnight?

9. At the Pelew islands, when it is 4 o'clock in the morning, where is it 9 in the evening?

10. When it is 8 o'clock in the morning at Boston, where is it 2 in the evening?

PROBLEM XII.

The hour of the day at any place given, to find the hour at any other given place.

Rule. Bring the first given place to the brass meridian, and set the index of the hour circle at the given hour; then turn the globe until the other place is brought under the brass meridian, and the index will point to the hour required.

1. When it is noon at Washington, what time is it at Portland?

Ans. ½ past 12 nearly.

2. When it is 6 o'clock in the morning at London, what is the time at Cairo?

3. When it is 4 o'clock at Oporto, what time is it at Rome?

4. When it is midnight at Hallowell, what time is it at New-Orleans?

5. When it is 10 o'clock in the evening at Amsterdam, what time is it at Archangel?

6. When it is 7 o'clock in the evening at Copenhagen, what is the hour at Smyrna?

7. When it is 9 o'clock in the morning at Montreal, what is the time at St. Louis?

8. When it is midnight at New-York, what is the hour at the mouth of the Columbia river?

9. When it is noon at Quito, what is the hour at Gibraltar?

10. When it is midnight at Pekin, what is the time at Damascus?

Obs. Some globes have two rows of figures on the hour circle, others but one; this difference in globes frequently occasions confusion.

PROBLEM XIII.

To find the antipodes, antœci, and periœci of any place.

Rule. 1. For the antipodes. Bring the given place to the brass meridian, observe its latitude; set the index of the hour circle at 12; then turn the globe on its axis until the index points to the other 12: in the same latitude in the opposite hemisphere are the antipodes required.

2. For the antœci. Find the latitude of the place, and in the same degree of latitude on the other side of the equator are the antœci required.

3. For the periœci. Bring the place to the brass meridian, and mark its latitude; set the index of the hour circle at 12; then turn the globe on its axis until the index points to the other 12; and

under the same degree of latitude are the periœci required.

1. Required the antipodes, antœci, and periœci of New-York.

2. Required the antipodes, antœci, and periœci of the following places:

Alexandria,	Cape of Good Hope,
Mexico,	Athens,
Cape Comorin,	Florence,
St. Helena,	Savannah,
Rome,	Upsal,
Bermudas,	Vienna,
Canton,	Isle of Bourbon.
Botany bay,	

Obs. 1. The antipodes are those people who live diametrically opposite to one another upon the globe, standing with feet towards feet, on opposite meridians and parallels. Being on opposite sides of the equator they have opposite seasons, winter to one when it is summer to the other; being on opposite meridians, it is noon to one, when it is midnight to the other.

2. The antœci are those people who live on the same meridian, and in equal latitudes on different sides of the equator. Being on the same meridian, they have the same hours, i. e. when it is noon to one it is noon to the other, &c. Being on different sides of the equator, they have opposite seasons at the same time.

3. The periœci are those who live on the same parallels of latitude but on opposite meridians; their latitude being the same, but their longitude differing 180°. Being in the same latitude, they have the same seasons; but being on opposite meridians, it is noon to the one when it is midnight to the other.

PROBLEM XIV.

The month, and day of the month, given, to find the sun's longitude, or place in the zodiac; and his declination.

Rule. Find the day of the month in the circle of months on the horizon, against which, in the circle of signs, is the sun's place in the zodiac; find the same sign and degree in the ecliptic on the surface of the globe; bring it to the meridian, and the degree over it is his declination.

1. Required the sun's longitude and declination on the 20th of August.

2. Required the sun's declination and longitude on the 4th of July.

3. Required the sun's longitude and declination on the 10th of January, 4th of February, 20th of March, 28th of April, 22d of May, 18th of June, 14th of July, 7th of August, 11th of October, 17th of November, 21st of December, 15th of September.

Obs. This problem may also be performed by the celestial globe.

The analemma may be used, if preferred, instead of the circle of signs on the horizon.

What is called the analemma on the globe, is a narrow slip of paper pasted on some vacant place on the globe, the length of which is equal to the breadth of the torrid zone. It is divided into months, and days of the month, corresponding to the sun's declination for every day in the year.

The sun's declination is his distance from the equator in degrees; and is north or south, as the sun's place in

the ecliptic is between the equinoctial and the north or the south pole.

PROBLEM XV.

To find those places in the torrid zone, having the sun vertical on any given day in the year.

Rule. Find the sun's declination; turn the globe on its axis, and to all places passing under the observed degree of the sun's declination, the sun will be vertical on that day.

1. Required those places having the sun vertical on the

1st of January,	12th of July,
2d of February,	14th of August,
4th of March,	16th of September,
6th of April,	18th of October,
8th of May,	20th of November,
10th of June,	24th of December,
4th of July,	22d of May.

PROBLEM XVI.

To rectify the globe for the latitude, zenith, and sun's place on any given day in the year.*

Rule. 1. For the latitude.—If the latitude be north, elevate the north pole as many degrees above the horizon, as will correspond with the latitude of the place. If the latitude be south, elevate the south pole as above directed.

* The zenith in this sense, is the highest point of the brass meridian above the horizon.

2. The place is then in its zenith.

3. Find the sun's place for the given day; bring it to the brass meridian, and set the index of the hour circle at the upper 12; place the north pole of the globe due north: the globe will then be in the position in which the earth actually is, on that day.

1. Rectify the globe for Boston, on the 16th of January,

London, on the 8th of February,
Paris, on the 14th of March,
New Orleans, on the 18th of April,
Cape Horn, on the 22d of May,
Rome, on the 24th of June,
New-York, on the 4th of July,
Baltimore, on the 25th of August,
Washington, on the 21st of September,
Mexico, on the 10th of October,
Lima, on the 12th of November,
Cape of G. Hope, on the 15th of December.

Obs. The latitude of any place, is equal to the elevation of the nearest pole of the heavens above the horizon of that place; and the poles of the heavens are directly over the poles of the earth, each 90° from the equinoctial line.

Let us be upon what place of the earth we may, if the limits of our view be not intercepted by hills, we shall see one half of the heavens, or 90° every way round from that point which is over our heads. Therefore, if we were upon the equator, the poles of the heavens would lie in our horizon, or limit of our view; if we go from the equator, towards either pole of the earth, we shall see the corresponding pole of the heavens rising gradually above our horizon, just as many degrees as we have gone from the equator; and if we were at either of the earth's poles, the corresponding pole of the heavens would be directly over our heads. Consequently, the elevation or height of the pole in degrees, above the

horizon, is equal to the number of degrees that the place is from the equator.

PROBLEM XVII.

To find at what hour the sun rises and sets, and the length of the day and night, at any place, on any given day in the year.

RULE. Find the latitude of the place, and rectify the globe for the latitude; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index of the hour circle at the upper 12; turn the globe on its axis eastward until the sun's place is level with the horizon, and the index will point to the hour of the sun's rising. Turn the globe on its axis westward until the sun is level with the western edge of the horizon, and the index will point to the hour of the sun's setting.

The hour of the sun's rising being doubled, shows the length of the night; and the hour of the sun's setting being doubled, shows the length of the day.

1. Required the time when the sun rises and sets, and the length of the day and night, at New-York, on the 20th of December.

2. Required the time when the sun rises and sets, and the length of the day and night, at Warsaw, on the 4th of January,
St. Petersburg, on the 18th of February,
London, on the 10th of March,
Amsterdam, on the 8th of April,
Paris, on the 22d of May,
Londonderry, on the 16th of June,
Madrid, on the 18th of July,

Naples, on the 20th of August,
Constantinople, on the 17th of September,
Aberdeen, on the 14th of October,
Glasgow, on the 12th of November.

Obs. The length of the longest day, at all places not in the frigid zone, may be found by the above-mentioned rule. The longest day in all places in north latitude, is on the 21st of June, when the sun is in his greatest declination north; and the longest day at all places in south latitude, is on the 21st of December, when the sun is in his greatest southern declination.

PROBLEM XVIII.

To find those days of the year on which the sun will be vertical at any given place in the torrid zone.

Rule. Bring the given place to the brass meridian, and mark its latitude; then turn the globe on its axis, and observe those two points of the ecliptic, which pass under that degree of latitude; look for these points of the ecliptic, in the circle of signs on the horizon, against which, in the circle of months, are the days required.

1. Required those two days of the year on which the sun will be vertical at

Lima,	Sierra Leone,
Mexico.	Manilla,
Havanna,	Sandwich Islands,
St. Helena,	Friendly Islands,
Pelew Islands,	Rio Janeiro,
Quito,	Cape Comorin,
Caraccas,	Canton,
St. Salvador,	Calcutta.

PROBLEM XIX.

To find the number of miles contained in a degree of longitude in any given parallel of latitude.

Rule. Find the distance, with a pair of compasses, between two meridians differing in longitude 15° in the given parallel of latitude; measure the number of degrees contained in this distance on the equator; multiply the number of degrees found by 4, and the product will be the number of geographical miles. Or, find the number of degrees contained between the two meridians 15 degrees distant, with the quadrant of altitude, and proceed as above directed.

1. Required the number of geographical miles contained in a degree of longitude in the latitude of Washington.

Obs. Any number of geographical miles, may be brought into English miles, by multiplying by 69½, and dividing by 60.

2. Required the number of geographical, and English miles contained in a degree of latitude at

Quito,	Edinburgh,
Mexico,	London,
Charleston,	Archangel,
Boston,	Warsaw,
Quebec,	Moscow,
Mount Hecla,	Cape Farewell,
Constantinople,	Madrid.

Obs. When Cary's large globes are used, as the me-

ridians are drawn 10° distant, we must read 10 instead of 15, and multiply by 6 instead of 4.

2. On small globes the meridians are drawn 15° distant: but on large globes, the meridians are generally drawn 10° distant.

PROBLEM XX.

To ascertain how far the inhabitants of any place are carried in an hour, by the rotation of the earth from west to east.

Rule. Find the number of miles contained in a degree of longitude in the latitude of the given place, which multiply by 15 for the distance required.*

Illus. The earth revolves 360°, or its whole circumference, in 24 hours; and 360°, divided by 24 hours, gives a movement of 15° an hour: hence the number of miles contained in a degree of longitude, being multiplied by 15, will produce the number of miles that any given place moves in an hour.

1. At what rate an hour are the inhabitants of New-York carried by the earth's rotation on its axis?

2. Required the number of geographical, and English miles, the inhabitants of the following places are carried in an hour, by the earth's rotation on its axis;

Aleppo,	Batavia,
Morocco,	Cape Horn,
Cape Farewell,	Cape of G. Hope,
Nootka Sound,	St. Petersburg,

* A table showing the number of miles contained in a degree of longitude in the latitude of any place, may be found in the fore part of the book.

New-Orleans,	Buenos Ayres,
Spitzbergen,	Delhi,
London,	Athens,
Philadelphia,	Savannah.

PROBLEM XXI.

The month, day, and hour of the day, given, to find where the sun is vertical at that instant.

RULE. After finding the sun's declination for the given time, and rectifying the globe for that place, bring the given place to the brass meridian, and set the index of the hour circle at the upper 12; if the given time be before noon, turn the globe westward as many hours as it wants of noon. If the given time be past noon, turn the globe eastward as many hours as the time is past noon; and the place exactly under the degree of the sun's declination, will be the place required.

1. At 4 o'clock in the evening at London, on the 25th of April, where is the sun vertical?

Ans. The sun being in 13° northern declination, the north pole must be elevated 13° above the horizon, and as the given time is 4 o'clock in the evening, the globe must be turned 4 hours eastward; the sun will then be vertical at Barbadoes.

2. At 10 o'clock in the morning at New-York, on the 14th of April, where is the sun vertical?

3. Where is the sun vertical, when it is 4 o'clock at New-York, on the 4th of July?

4. When it is 4 o'clock in the morning at London, on the 18th of August, where is the sun vertical?

5. When it is 11 o'clock in the morning at Cal-

cutta, on the 11th of April, where is the sun vertical?

6. When it is 3 o'clock in the evening at London, on the 5th of January, where is the sun vertical?

7. When it is ten minutes after 5 o'clock in the evening at Philadelphia, on the 10th of May, where is the sun vertical?

PROBLEM XXII.

To find the sun's declination and the day of the month, by having the length of the day at any place given.

Rule. After bringing the given place to the brass meridian, and setting the index of the hour circle at the upper 12, turn the globe on its axis eastward, until the index shall have passed over as many hours as are equal to half the number of hours in the given day; elevate or depress the pole until the place is level with the eastern semicircle of the horizon, and the distance of the elevated pole from the horizon, will be the sun's declination. Turn the globe on its axis, and observe what two points of the ecliptic pass under the sun's declination; find these points in the circle of signs on the horizon, and exactly against them, in the circle of months, are the days of the month required.

1. Required the sun's declination, and those two days in the year which are each 16 hours long at London.

Ans. The sun's declination is about 21° north. The days are the 24th of May, and the 17th of July.

2. Required the sun's declination, and those days of the year which are each 13 hours long at New-York.

3. On what two days of the year does the sun set at half past 7 o'clock at Edinburgh.

4. What two days in the year are each 14 hours long at Quebec; and what is the sun's declination?

5. Required the sun's declination, and those two days which are each 11 hours long at Boston.

6. Required the sun's declination, and those two days in the year which are each 14 hours long at Portland.

7. Required the sun's declination, and those two days which are each 16 hours long at St. Petersburg.

8. Required the sun's declination, and those two days which are each 11 hours long at Philadelphia.

PROBLEM XXIII.

To find the sun's amplitude at any given place.

Rule. Rectify the globe for the latitude of the place; find the sun's place in the ecliptic, and bring it to the eastern semicircle of the horizon, and the number of degrees from the sun's place to the east point of the horizon, will be the sun's rising amplitude. Bring the sun's place in the ecliptic to the western semicircle of the horizon, and the number of degrees from the sun's place to the western point of the horizon, will be the sun's setting amplitude.

1. Required the sun's rising and setting amplitude at Washington, on the fourth of July.

2. Required the sun's rising and setting amplitude at New-York, on the 16th of September.

3. Required the sun's rising and setting amplitude at Vienna, on the 20th of August.

4. Required in what point of the compasses the sun rises and sets at the mouth of Oregon, or Columbia river, on the 22d of May

5. Required the sun's rising and setting amplitude at the Cape of Good Hope, on the 10th of June.

6 Required in what point of the compasses the sun rises and sets at St. Salvador, on the 14th of October.

7. Required the sun's rising and setting amplitude at Boston, on the 15th of December.

8. Required the sun's rising and setting amplitude at Archangel, on the 18th of January, Amsterdam, on the 20th of February, Paris, on the 24th of March, and Madrid, on the 25th of April.

PROBLEM XXIV.

Given the length of the longest day, to find the latitude of a place not within the polar circles,

Rule. If the place be in north latitude, bring the first point of Cancer, and if in south latitude, the first point of Capricorn, to the brass meridian; set the index of the hour circle at the upper 12; turn the globe on its axis westward, until the index shall have passed half as many hours as are equal to the length of the given day; elevate or depress

the pole, until the sun's place, Cancer or Capricorn, is brought to the north point of the horizon, and the elevation of the pole will show the latitude required.*

1. In what degree of south latitude is the longest day 14 hours?

2. In what degree of south latitude is the longest day 13 hours?

3. In what degree of north latitude is the longest day 18 hours?

4. In what degree of north latitude is the longest day 16½ hours?

5. In what latitude is the night 13 hours long, on the 14th of December?

6. In what latitude is the longest day 15 hours long?

7. In what degree of north latitude is the 20th of May 16 hours long?

8. In what degree of south latitude does the sun rise at 7 o'clock on the 5th of April?

PROBLEM XXV.

To find the length of the longest day at any given place in the north frigid zone.

Rule. Bring the given place to the north point of the horizon; observe its distance from the north pole, on the brass meridian; mark the number of degrees from the equator towards the pole; then turn the globe on its axis, and observe what two points of the ecliptic pass under the mark above;

* This rule will answer for any other given day, by finding the sun's place for that day, and using it instead of Cancer and Capricorn.

find these two points in the circle of signs on the horizon, against which, in the circle of months, are the days on which the longest day begins and ends.

The longest day at the given place, begins on a day preceding, and ends on a day succeeding, the 21st of June.

1. Required the length of the longest day at the north Cape, in the Island of Mageroe, in latitude 71° 31′ north.

Ans. The place is 18½° from the pole; the longest day begins on the 14th of May, and ends on the 30th of July.—The day is therefore 77 days long, i. e. the sun is 77 natural days above the horizon.

2. Required the length of the longest day in 80 degrees north latitude.

3. Required the length of the longest day in 85 degrees north latitude.

4. Required the length of the longest day in latitude 75 degrees north.

5. Required the length of the longest day in latitude 82 degrees north.

6. Required the length of the longest day at the north pole.

7. Required the length of the longest day at the mouth of Mackenzie's river.

8. Required the length of the longest day at the south pole.

Obs. 1. The above-mentioned rule is general, and may be applied to the south frigid zone as well as the north, by reading the 21st of December for the 21st of June.

2. All places whose latitude is more than 66½ degrees, are in the frigid zone; and to those places the sun does not set, or is above the horizon, during several rotations of the earth on its axis.

3. A table showing the length of the longest day in almost all latitudes, will be found in the fore part of the book.

PROBLEM XXVI.

To find the sun's meridian altitude on any day at any given place.

Rule. Elevate the pole as many degrees above the horizon as are equal to the latitude of the place; find the sun's place in the ecliptic, bring it to the brass meridian, and the number of degrees contained on the brass meridian, between the sun's place and the horizon, reckoning the nearest way, will be the altitude required,

1. Required the sun's meridian altitude at London, on the 21st of June.

Ans. 62 degrees.

2. Required the sun's meridian altitude at New-York, on the 4th of September.

3. Required the sun's meridian altitude at Charleston, on the 7th of July

4. Required the sun's meridian altitude at Cape Horn, on the 18th of January.

5. Required the sun's meridian altitude at Boston, on the 18th of November.

6. Required the sun's meridian altitude at Stockholm, on the 4th of August.

7. What is the sun's meridian altitude on the 17th of April, at the mouth of Columbia river?

Obs. The sun's altitude at any time, is his height in degrees above the horizon at that time.

The sun's meridian altitude is his height above the horizon at noon.

PROBLEM XXVII.

To find the degree of latitude, and those places in the north frigid zone, where the sun begins to shine constantly without setting, on any given day between the 21st of March and the 21st of June.

Rule. Find the sun's place in the ecliptic for the given day, bring it to the brass meridian, and observe his declination; subtract the degrees of the sun's declination from 90, and the remainder will be the latitude required; turn the globe on its axis, and at all places passing under this degree, the sun begins to shine constantly without setting during several revolutions.

1. Required in what latitude, and at what places, the sun begins to shine without setting, on the 14th of May.

Ans. The sun's declination, 18½ degrees, being subtracted from 90°, leaves 71½° for the latitude; the places passing under this latitude, are North Cape in Lapland, Icy Cape in the southern part of Nova Zembla, &c.

2. Required in what latitude, and at what places, the sun begins to shine constantly on the 21st of April.

3. Required in what latitude north, and at what places, the sun begins to shine constantly on the 30th of March.

4. Required in what latitude north, and at what places, the sun begins to shine constantly on the 16th of April.

5. Required in what latitude north, and at what

places, the sun begins to shine constantly on the 24th of May.

6. In what latitude north, and at what places, does the sun begin to shine constantly on the 4th of June?

7. Required in what latitude south, and at what places, the sun begins to shine constantly on the 20th of November.

Obs. For the south frigid zone, we may take any day between the 23d of September and the 21st of December, and proceed as above directed.

PROBLEM XXVIII.

To find that part of the equation of time, which depends upon the obliquity of the ecliptic.

Rule. Find the sun's place in the ecliptic, and bring it to the brass meridian; count the number of degrees from Aries to the brass meridian on the *ecliptic*, and on the *equator*, and the difference between them, reckoning 4 minutes of time to a degree, is the equation of time. If the number of degrees on the equator, exceed those on the ecliptic, the sun is slower than the clock; if the number of degrees on the ecliptic, exceed those on the equator, the sun is faster than the clock.

1. Required the equation of time, depending on the obliquity of the ecliptic, on the 17th of July.

Ans. As the degrees on the equator exceed those on the ecliptic 2°, the sun is 8 minutes slower than the clock.

2. Required the equation of time on the 18th of October.

3. What is the equation of time on the 14th of February?

4. What is the equation of time on the 16th of April?

5. What is the equation of time on the 22d of May?

6. When the sun is in 24° of Cancer, what is the equation of time?

7. On what 4 days in the year does the sun and clock agree in time?

8. Required the equation of time on the 4th of July.

NOTE. The earth's motion on its axis being perfectly equable, and thereby causing an apparent equable motion of the starry heavens around the same axis, produced to the poles of the heavens; it is plain that equal portions of the celestial equator, pass over the meridian in equal parts of time, because the axis of the world is perpendicular to the plane of the equator. Therefore, if the sun kept its annual course in the celestial equator, it would always revolve from a meridian to the same meridian again in 24 hours exactly, as shown by a well regulated clock.

But as the sun moves in the ecliptic, which is oblique, both to the plane of the equator, and the axis of the world, it cannot always revolve from a meridian to the same meridian again in 24 equal hours; but sometimes a little sooner, and at other times a little later, because equal portions of the ecliptic pass over the meridian in unequal parts of time, on account of its obliquity. This difference is the same in all latitudes.

PROBLEM XXIX.

Given the day and hour at any place, to find the sun's azimuth and altitude.

RULE. Rectify the globe for the latitude of the place, and screw the quadrant of altitude on the

meridian over the latitude; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index of the hour circle at the upper 12; then if the given time be before noon, turn the globe on its axis eastward as many hours as it wants of noon; if the given time be past noon, turn the globe westward as many hours as it is past noon; bring the graduated edge of the quadrant of altitude to agree with the sun's place, and the number of degrees on the horizon, reckoning from north or south, to the graduated edge of the quadrant, will show the sun's azimuth; and the number of degrees on the quadrant, counting from the horizon to the sun's place, will be the altitude required.

1. Required the sun's azimuth and altitude from the north, at London, on the 1st of May, at 10 o'clock in the morning

Ans. The azimuth from the north is 135°, or from the south 45°, and the altitude 47°.

2. Required the sun's azimuth and altitude at New-York, on the 4th of July, at 9 o'clock in the morning.

3. What is the sun's azimuth and altitude at Boston, on the 16th of December, at 7 o'clock in the evening?

4. Required the sun's azimuth and altitude at Philadelphia, on the 22d of May, at 10 o'clock in the morning.

5. What is the sun's altitude and azimuth at Vienna, on the 17th of June, at 5 o'clock in the evening?

6. Required the sun's azimuth and altitude at Paris, on the 4th of February, at 4 o'clock in the evening.

7. Required the sun's azimuth and altitude at

Copenhagen, on the 7th of July, at 7 o'clock in the morning.

8. Required the sun's azimuth and altitude at Rome, on the 15th of March, at 6 o'clock in the morning.

PROBLEM XXX.

To illustrate the seasons of the year, and the different lengths of day and night.

Rule. Rectify the globe for the sun's declination, and the different portions of the parallels of latitude above the horizon, corresponding to the degree of the elevation, will show the length of the day in each respective latitude.

1. *For the equinoxes.* The sun having no declination at this time, place the two poles of the globe in the horizon; and the point Aries being brought to the eastern edge of the horizon, the point Libra will be in the western edge. When the sun appears to be rising at the meridian of Libra, he appears to be setting at the meridian of Aries; and by turning the globe on its axis gently eastward, the sun will appear to move westward; and to be setting at all places as they successively disappear below the eastern edge of the horizon, and to be rising at all places as they successively emerge above the western edge of the horizon.

It will be noon at these places as they pass the upper, and midnight as they pass the lower semicircle of the brass meridian.

During the period of the earth's rotation, every place on its surface is 12 hours in the dark, and 12 hours in the enlightened hemisphere; consequently the days and nights are equal all over the globe. The sun's meridian altitude at each place will equal the complement of its latitude. Thus the sun's meridian altitude at New-York, is 49° 20′.

At the equator the sun will be vertical at all places as they pass the upper semicircle of the brass meridian.

And at all places on the equator, the sun's meridian altitude is 90°; but at the poles the sun having no altitude, he will appear to glide along the horizon during the whole space of 24 hours. At all places in north latitude, the sun will appear south; and at all places in south latitude, he will appear north when on the meridian.

2. *For the summer solstice.* To the inhabitants in north latitude, the summer solstice happens on the 21st of June, when the sun enters Cancer, or is in 23° 28′ north declination Rectify the globe for this declination, and bring the first degree of Cancer to the brass meridian; the equator will then be divided into two equal parts, Aries being in the western, and Libra in the eastern edge of the horizon. At this time the day is 12 hours long at the equator. And from the equator northward as far as the arctic circle, the diurnal arcs will exceed the nocturnal arcs, i e more than one half of any parallel of latitude will be above the horizon; consequently, the days are longer than the nights All the parallels of latitude within the arctic circle being above the horizon, those places within this circle will have constant day; and all parallels within the antarctic circle being below the horizon, those places will have constant night.

By counting the number of meridians between the brass meridian and the horizon in any latitude, reckoning an hour of time to every meridian or 15 degrees, half the length of the day will be determined; this doubled, gives the whole length of the day. Thus, in 30° north latitude there are seven meridians above the horizon between it and the brass meridian; consequently the length of the day is 14 hours. The sun will be vertical at all places at the tropic of Cancer as they successively pass the brass meridian.

Any place being brought to the brass meridian, its distance from the horizon, reckoned on the brass meridian the nearest way, will equal the sun's meridian altitude. Thus the sun's meridian altitude at Philadelphia, is 73½ degrees. The farther the sun apparently moves northward, the more daylight will be diffused over the north polar regions; and the sun will gradually appear to increase in altitude at the pole until the 21st of June, when his height is 23½ degrees: his height will then gradually decrease until the 23d of September; consequently the sun will be seen six months at the north pole.

3. *For the winter solstice.* To the inhabitants of northern latitudes, the winter solstice takes place on the 21st of December, at the time the sun enters Capricorn, when his declination is 23° 28′ south. Rectify the globe for this declination; bring the first degree of Capricorn to the brass meridian, and suppose the sun to be at a distance directly over it. As at the summer solstice, the days at the equator will be 12 hours long; but the equinoctial point Aries will be in the eastern part of the horizon, and Libra in the western.

All the parallels of latitude within the antarctic

circle, will be entirely above the horizon; while all the parallels within the arctic circle, will be wholly below the horizon; the inhabitants south of the equator have their longest day, while those north of the equator have their longest night.

The sun will be vertical at all places in the tropic of Capricorn, as they are successively brought to the meridian The sun's meridian altitude will be found to be greater in south latitude, and less in north latitude, contrary to the summer solstice. Thus the sun's meridian altitude at London will be 15° instead of 62°; at Philadelphia 26½° instead of 73½°, making a difference of 47° nearly, or the width of the torrid zone.

At the time the sun enters Libra, on the 23d of September, the south pole begins to be enlightened, and the sun will gradually increase in altitude until the 21st of December, when he is 23° 28′ in height, and at his greatest southern declination; then he gradually diminishes in altitude and declination until the 21st of March, when he again enters Aries, and appears to skim along the horizon at both poles as at first.

PROBLEM XXXI.

To find the sun's altitude for any given time at any place.

RULE. Elevate the pole to the sun's declination, fix the quadrant in the zenith, bring the given place to the brass meridian, and set the index of the hour circle at the upper 12; then if the hour

be in the morning, turn the globe westward, but if in the evening, turn it eastward, as many hours as the time is before or after 12; extend the quadrant of altitude over the given place, and the degree on the quadrant over the place, will be the sun's altitude required.

1. Required the sun's altitude at Washington, on the 21st of June, at 3 o'clock in the evening.

Ans. 51½ degrees.

2. Required the sun's altitude at NewYork, on the 30th of April, at 10 o'clock in the morning.

3. Required the sun's altitude at London, on the 17th of July, at 4 o'clock in the evening.

4. Required the sun's altitude at Edinburgh, on the 12th of September, at 9 o'clock in the morning.

PROBLEM XXXII.

Given the day and hour, to find all those places where the sun has the same altitude as any other given place.

RULE. Find the place where the sun is vertical at the given time, by problem 21; ascertain its distance from the place given, and all those places that are at the same distance from it as the given place, will be the places required.

1. Required all those places where the sun will have the same altitude as NewYork, on the 30th of April, at ¼ past 8 in the morning.

Ans. The sun will be vertical at Cape Verd: Quebec, Moscheto Cove in Greenland, the western part of St.

Domingo, Cumberland Harbour in Cuba, St Salvador in the West Indies, &c. are at the same distance from New-York.—These will be the places required.

2. Required all those places having the same altitude as Washington, on the 22d of May, at 4 o'clock in the evening.

3. Required all those places having the same altitude as Boston, at 10 o'clock in the morning, on the 14th of February.

4. When it is noon at London, on the 20th of March, required those places where the sun will have the same altitude as London.

PROBLEM XXXIII.

Any place on the globe being given, to find all those places that are at the same distance from it as any other given place.

Rule. With a pair of compasses take the extent between both places, describe a circle having the first given place in the centre, and all those in the circumference of the circle, will be the places required.

Or, place the quadrant of altitude over both places, so that the part marked 0 may be on the first given place; mark the degree over the other place, and describe a circle with the quadrant. When the quadrant is not long enough, extend a thread between the two places, and describe a circle as above.

1. Required all those places that are at the same distance from Constantinople as Paris.

2. Required all those places that are at the same distance from Washington as New-York.

3. Required those places having the same distance from London as Rome.

4. Required all those places having the same distance from Alexandria as Algiers.

PROBLEM XXXIV.

Given any number of days not greater than $186\frac{1}{2}$ *in north, or* $178\frac{1}{2}$ *south latitude, to find the latitude in which the sun does not set during the given time.*

RULE. In the circle on the horizon, count half the given number of days from the 21st of June, or the 22d of December, as the place may be in north or south latitude, eastward or westward;* and ascertain the sun's declination corresponding to the days when the reckoning ends, by problem 14; the same number of degrees reckoned from either pole, on the brass meridian, will be the latitude required.

1. Required the degree of north latitude where the sun continues above the horizon 134 natural days.

Ans. 67 days (half of the given number) being counted from the 21st of June eastward, will correspond to the 15th of April, or being counted westward to the 27th of August; the sun's declination on either of these days being 10° north, the latitude required will be 80° north.

* If the given place be in north latitude, reckon from the 21st of June eastward; but if it be south latitude, reckon from the 22d of December westward.

2. Required the latitude where the sun is 116 days above the horizon.

3 Required in what degree of north latitude the sun will be 48 days above the horizon.

4. Required in what latitude the sun continues 96 days above the horizon.

PROBLEM XXXV.

*To find the breadth of the several climates from the equator to the poles.**

RULE. For the northern hemisphere, elevate the north pole 23° 28′ above the horizon, bring the first degree of Cancer to the meridian, and set the index of the hour circle at 12; turn the globe on its axis eastward until the index shall have passed over $\frac{1}{4}$ of an hour; then mark with a lead pencil, that point of the meridian passing through Libra, and intersected by the horizon; continue this rotation of the globe until the index shall have passed over another quarter of an hour, and mark as before, and so on until the meridian passing through Libra, will no longer intersect the horizon; bring these marks severally to the brass meridian, and they will show the latitudes where each climate ends, from the equator to the arctic circle; their difference will be the breadth between them severally.

For the climates within the polar circles, ascertain the latitude answering to the length of the longest day in each climate, for one month, two months, &c. which will be the latitude where all

* A table showing the breadth of the several climates may be found at page 54.

the climates severally end; the difference of which will be the breadth of each climate.

1. Required the breadth of the 6th climate.

Ans. Extent, from 36° 31′ to 41° 24′ north—Breadth 4° 59′.

2. Required the breadth of all the climates severally.

Obs. On Adam's and Cary's globes the above-mentioned marks are not necessary, as the meridian passing through Libra, is divided into degrees the same as the brass meridian; and the horizon will intersect this meridian in the several degrees corresponding to the end of each climate.

PROBLEM XXXVI.

To represent the natural position of the earth by placing the globe in the sunshine.

Rule. With the mariner's compass, (allowing for variation if any,) place the globe due north and south, bring the place in which you are to the meridian, and elevate the pole to the latitudes; the globe will then agree in every respect with the situation of the earth itself at that time.—All the circles of the globe, will correspond with the same imaginary circles in the heavens; and every kingdom, state, and town laid down on the globe, will have the same relative situations as the real ones, which they represent on the surface of the earth.

PROBLEM XXXVII.

The latitude, sun's place, and altitude being given, to find the sun's azimuth, and the hour of the day.

RULE. After having rectified the globe for the latitude, zenith, and sun's place, and set the index of the hour circle at 12, turn the globe eastward or westward, according as the sun's altitude may be given in the forenoon or afternoon, until the sun's place agrees with the given degree of altitude on the quadrant; the hours passed over by the index, will then show the time from noon, and the quadrant will point out the azimuth on the horizon.

1. When the sun's altitude at New-York, on the morning of the 21st of June, is 30 degrees, required the hour of the day, and the sun's azimuth.

Ans. 7 hours 20 minutes from noon,—azimuth 83½ from the north towards the east.

2. When the sun's altitude at London, on the afternoon of the 22d of May, is 35 degrees, required the hour of the day, and the sun's azimuth.

3. At Boston, when the sun's altitude on the 17th of August, is 40 degrees, required his azimuth, and the hour of the day.

4. On the 4th of July when the sun's altitude at Washington in the morning is 42°, required the hour of the day, and the sun's azimuth.

OBS. If the sun's altitude be given in the morning, turn the globe eastward, if in the evening, westward.

PROBLEM XXXVIII.

Given the latitude of the place, and day of the month, to find when the sun is due east and west.

RULE. Rectify the globe for the latitude, zenith, and sun's place; after setting the index at 12, move the quadrant until the mark 0 is brought to the east point of the horizon; keep the quadrant in this position, turn the globe on its axis until the sun's place is brought to the graduated edge of the quadrant, and the hours passed over by the index, will be the time from noon when the sun is due east, and at the same time from noon he will be due west.

1. Required the hour when the sun is due east or west, on the 21st of June, in latitude 40° 43′.

Ans. At about 41 minutes past 8 in the morning, the sun is due east, and at about 19 minutes past 3 in the afternoon, the sun is due west.

2. On the 19th of May at London, at what hours will the sun be due east or west?

3. At what hours will the sun be due east and west at New-York, on the 20th of August?

4. On the 16th of December at Washington, at what hours will the sun be due east and west?

PROBLEM XXXIX.

Given the day and hour when a solar eclipse will happen, to find where it will be visible.

RULE. Ascertain the place where the sun will be vertical at the given hour, by problem 21; and

at all places within about 35° of the place where the sun is vertical, the eclipse may be visible, particularly if it be a total eclipse.

1. There being an eclipse of the sun observed at Greenwich on the 3d of March, beginning 17 m. past noon, middle 46m. past 1, and ending 9m. past 3; required those places where the eclipse will be visible.*

Ans. In all of Europe, and a great portion of America, Asia, and Africa. The eclipse will be annular along the central track of the penumbra as in Iceland, at their 12 o'clock. As the sun's apparent diameter exceeded the moon's, at that time, it will be no where a total eclipse.

PROBLEM XL.

Given the day and hour when a lunar eclipse will happen, to find all those places on the globe where it will be visible at that time.

Rule. Ascertain the sun's place for the given time, elevate the pole farthest from the sun's place, to the observed degree of declination; bring the place where the hour is given to the brass meridian, and set the index at 12; if the given time be in the morning, turn the globe westward, but if in the afternoon, turn it eastward, as many hours as the time is before or after noon; and the people precisely under the sun's declination, will be the antipodes of the people where the moon is eclipsed vertically. Keep the globe in this position, and set the index again at 12, then turn it until the index shall have passed over 12 hours; and at all

* For more examples, see table of eclipses, page 47.

those places above the horizon, the eclipse will be visible; at those places along the western edge of the horizon, the eclipsed moon will be rising; at those along the eastern, it will be setting; and at the place precisely under the zenith, it will be eclipsed vertically.

1. At New-York, on the 10th of March, the beginning of a lunar eclipse being 13m. past 12 at night, and the end 48m. past 2 in the morning, apparent time, required those places where it will be visible.*

Ans. The sun is found to be in about 4½° south declination; the north pole must be elevated to this declination, and New-York brought to the meridian; let 11 hours 47 minutes, the time before noon, be taken, and the problem performed according to the rule, and the eclipse will be found visible in all America, the greater part of Europe, and a part of Africa.

Obs. Lunar Eclipses continuing for a considerable time, may be visible in more than one hemisphere of the earth, during the eclipse. This is owing to the motion of the earth on its axis.

Concluding remarks on the Terrestrial Globe.

1. The latitude of any place is equal to the elevation of the pole above the horizon of that place, and the elevation of the equator is equal to the complement of the latitude.

2. Those places which lie on the equator, have no latitude, it being there that latitude begins; and those places which lie on the first meridian, have no longitude, it being there that longitude begins. Consequently that particular place of the earth, where the first meridian intersects the equator, has neither latitude nor longitude.

3. At all places of the earth except the poles, all the points of the compass may be distinguished in the hori-

* For more examples see table p. 47.

zon; but from the north pole every place is considered south; and from the south pole every place is considered north. Hence as the sun is constantly above the horizon of each pole for half a year in its turn, he cannot be said to depart from the meridian of either pole, for half a year together. Consequently, at the north pole it may be said to be noon every moment for half a year; and let the winds blow from what part they may, they must always blow from the south; and at the south pole they must always blow from the north.

4. As one half of the ecliptic is above the horizon of the pole, and the sun, moon, and planets, move nearly in the ecliptic, they will all rise and set at the poles. But, because the stars never change their declinations from the equator, (at least not sensibly in any age,) those which are once above the horizon of either pole, never set below it, and those which are once below it never rise.

5. Every place of the earth equally enjoys the benefit of the sun, in respect of time, and are equally deprived of it.

6. All places upon the equator have their days and nights equally long, i. e. 12 hours each, at all times of the year For although the sun declines, alternately from the equator towards the north and south, yet, as the horizon of the equator cuts all the parallels of latitude and declination into halves, the sun must always continue above the horizon for one half of a diurnal revolution about the earth, and for the other half below it.

7. When the sun's declination is greater than the latitude of any place, upon either side of the equator, the sun will come twice to the same azimuth or point of the compass in the forenoon, at that place, and twice to a like azimuth in the afternoon; that is, he will go twice back every day, while his declination continues to be greater than the latitude. Thus, supposing the globe to be rectified to the latitude of Barbadoes, which is 13 degrees north, and the sun to be any where in the ecliptic, between the middle of Taurus and the middle of Leo; if the quadrant of altitude be set at about 18 degrees north of the east in the horizon, the sun's place be marked with a lead pencil upon the ecliptic, and the globe be then turned westward on its axis, the said mark

will rise in the horizon a little to the north of the quadrant, and thence ascending, it will cross the quadrant towards the south; but before it arrives at the meridian, it will cross the quadrant again, and pass over the meridian northward of Barbadoes. And if the quadrant be set about 18 degrees north of the west, the sun's place will cross it twice, as it ascends from the meridian towards the horizon, in the afternoon.

8. At all places of the earth between the equator and the poles, the days and nights are of equal length (12 hours each) when the sun is in the equinoctial; for, in all elevations of the pole, short of 90 degrees, one half of the equator or equinoctial will be above the horizon, and the other half below it.

9. The days and nights are never of an equal length at any place between the equator and polar circles, but when the sun enters the signs Aries and Libra. For, in every other part of the ecliptic, the circle of the sun's daily motion is divided into two unequal parts by the horizon.

10. The nearer a place is to the equator, the less is the difference between the length of the days and nights in that place; and the more remote, the contrary. The circles which the sun describes in the heavens, every 24 hours, being cut more nearly equal in the former case, and more unequally in the latter.

11. At all places lying upon any given parallel of latitude, however long or short the day or night be at any one of these places, at any time of the year, it is then of the same length at all the rest; for, in turning the globe on its axis, when rectified according to the sun's declination, all these places will be equally long above or below the horizon.

12. The sun is vertical twice a year to every place between the tropics; to those under the tropics, once a year, but never any where else. For there can be no place between the tropics, but that there will be two points in the ecliptic, whose declination from the equator is equal to the latitude of that place; and but one point of the ecliptic which has a declination equal to the latitude of places on the tropic, which that point of the ecliptic touches; and as the sun never goes without the tropics, he can never be vertical to any place that lies without them.

13. At all places in the torrid zone, the duration of the twilight is less, because the sun's daily motion is more perpendicular to the horizon. In the frigid zones, greater; because the sun's daily motion is nearly parallel to the horizon; and therefore he is the longer in passing 18 degrees below it, until which time the twilight always continues. And in the temperate zones, it is at a meridian between the two, because the obliquity of the sun's daily motion is so.

14. At all places lying exactly under the polar circles, the sun, when he is in the nearest tropic, continues 24 hours above the horizon without setting; because no part of that tropic is below their horizon. And when the sun is in the farthest tropic, he is for the same length of time without rising, because no part of that tropic is above their horizon. But at all other times of the year, he rises and sets there, as in other places, because all the circles that can be drawn parallel to the equator, between the tropics, are more or less cut by the horizon, as they are farther from, or nearer to that tropic which is all above the horizon; and when the sun is not in either of the tropics, his diurnal course must be in one of these circles.

15. At all places in the northern hemisphere, from the equator to the polar circles, the longer day and shorter night is when the sun is in the northern tropic; and the shorter day and longer night is when the sun is in the southern tropic; because no circle of the sun's daily motion is so much above the horizon, and so little below it, as the northern tropic; and none so little above it, and so much below it, as the southern. In the southern hemisphere, the contrary.

16. At all places between the polar circles and poles, the sun appears for some number of days, or rather some number of diurnal revolutions, without setting: and at the opposite time of the year, without rising; because some parts of the ecliptic never set in the former case, and as much of the opposite never rise in the latter. And the nearer, or the more remote from the pole, these places are, the longer or shorter is the continuance of the sun's presence or absence.

17. If a ship sets out from any port, and sails round the earth eastward to the same port again, let her oc-

cupy what time she may on the voyage, the sailors in reckoning their time, will gain one complete day at their return, or count one day more than those who reside at the same port; because by going contrary to the sun's diurnal motion and being more forward every evening than they were in the morning, their horizon will get sooner above the setting sun, than if they had been for a whole day at the same place. And thus, by cutting off a part proportionable to their own motion, from the length of every day, they will gain a complete day of that sort at their return, without absolutely gaining one moment of time more than is elapsed during their course, to the people of the port. If they sail westward, they will reckon one day less than if they had remained at the port, because by gradually following the apparent diurnal motion of the sun, they will keep him each particular day so much longer above their horizon, as will answer to that day's course; and by that means, they will cut off a whole day in reckoning at their return, without absolutely losing one moment of time.

Hence, if two ships should set out at the same time from any port, and sail round the globe, one eastward and the other westward, so as to meet at the same port on any other day whatever, they will differ two days in reckoning their time at their return. If they sail twice round the earth, they will differ four days,&c., making two days difference each time.

Of the Celestial Globe.

1. In treating of the celestial globe, it may be observed, that as the equator, ecliptic, tropics, polar circles, horizon, and brass meridian, are exactly alike on both globes, all the former problems concerning the sun, rectifying the globe, &c., are performed in the same way by both globes.

2. The *latitude* and *longitude* of the stars, and other celestial bodies, are not reckoned as they are on the terrestrial globe; for all terrestrial latitudes are reckoned from the equator, and longitudes from the meridian, of some remarkable place, as, London by the English, Paris by the French, Washington by the citizens of the United States, &c. But the astronomers of all nations agrée in reckoning the latitude of the celestial bodies from the ecliptic; and their longitude from the equinoctial colure, where it cuts the beginning of Aries ♈, eastward, quite round the globe to the same point again. Consequently those stars which lie between the equinoctial and the northern half of the ecliptic, have north declination and south latitude; those lying between the equinoctial and the southern half of the ecliptic, have south declination and north latitude; and all those lying between the tropics and poles, have their declination and latitudes of the same denomination.

3. There are six great circles on the celestial globe, which cut the ecliptic perpendicularly, and meet in two opposite points in the polar circles; which points are each 90 degrees from the ecliptic, and are called its poles. These polar points divide those circles into 12 semicircles; which cut the ecliptic at the beginning of the 12 signs. They resemble so many meridians on the

terrestrial globe, and as all places lying under any particular meridian semicircle on that globe, have the same longitude, so all those points of the heavens. through which any one of the above semicircles are drawn, have the same longitude. And as the greatest latitudes on the earth, are at the north and south poles of the earth, so the greatest latitude in the heavens, are at the north and south poles of the ecliptic.

4. In order to distinguish these stars, with regard to their situations and positions in the heavens, the ancients divided the whole visible firmament of stars into particular systems, which they called constellations; and digested them into the forms of such animals as are delineated upon the celestial globe. And those stars which lie between the figures of those imaginary animals, and could not be brought within the compass of any of them, were called *unformed stars*.

5. Because the moon and all the planets were observed to move in circles or orbits which cross the ecliptic, or line of the sun's path, at small angles, and to be on the north side of the ecliptic for one half of their course round the heaven of stars, and on the south side of it for the other half, but never to go quite 8 degrees from it on either side, the ancients distinguished that space by two small circles, parallel to the ecliptic, one on either side, at 8 degrees distance from it.

6. And the space included between these circles, they called the *zodiac*, because most of the 12 constellations placed therein, resemble some living creature.

7. It may here be observed, that in the infancy of astronomy, these 12 constellations stood at, or near the places of the ecliptic, where the above characters are marked on the globe; but now each constellation has advanced a whole sign, on account of the recession of the equinoctial points from their former places. Thus the constellation *Aries* is now in the former place of Taurus, Taurus in the former place of Gemini, and so on.

8. The stars appear of different magnitudes to the eye; probably because they are at different distances from us. Some of the most remarkable have names given them, as *Castor* and *Pollux* in the head of the

Twins, *Sirius* in the mouth of the *Great Dog*, *Procyon* in the side of the *Little Dog*, *Arcturus* in *Böotes*, &c.

Having premised these observations, we shall endeavour to introduce all the most useful problems to be performed by the learner, together with an alphabetical list of the constellations, showing the *right ascension* and *declination* of the middle of each, that they may the more readily be pointed out on the globe.

Alphabetical List of the Constellations.

		Righ. Ascen.	*Declin.*
[illegible]	Andromeda. N.	14	34 N.
6	Antinöus. N.	292	0
34	Apus, vel Avis Indica. S. . . .	252	75 S.
11	Aquarius. Z.	335	4 S.
6	Aquila. N.	295	8 N.
28	Ara. S.	55	55 S.
1	Aries. Z.	30	22 N.
15	Argo Navis. S.	115	50 S.
[illegible]	Asterion et Chara. N.	200	40 N.
33	Auriga. N.	75	45 N.
1[illegible]	Böotes. N.	212	20 N.
12	Brandenburgium Sceptrum. S. .	67	15 S.
32	Cameleopardalus. N.	68	70 N.
4	Cancer. Z.	128	20 N.
15	Canis Major. S.	105	20 S.
5	Canis Minor. S.	120	5 N.
10	Capricornus. Z.	310	20 S.
31	Caput Medusæ. N.	44	40 N.
30	Cassiopeia. N.	12	60 N.
20	Centaurus. S.	200	50 S.
29	Cepheus. N.	338	65 N.
1	Cetus. S.	25	12 S.
13	Cerberus. N.	271	22 N.
27	Chamœleon. S.	175	78 S.
23	Circinus. S.	222	64 S.
14	Columba Noachi. S.	85	35 S.
9	Coma Berenices. N.	185	26 N.
25	Cor Caroli. N.	191	39 N.

		Right Ascen.	Declin.
30	Corona Australis. S.	278	40 S.
12	Corona Borealis. N.	235	30 N.
19	Corvus. S.	185	15 S.
18	Crater. S.	168	15 S.
25	Crux. S.	183	60 S.
27	Cygnus. N.	308	42 N.
17	Delphinus. N.	308	15 N.
44	Dorado or Xiphias. S.	75	62 S.
26	Draco. N.	270	66 N.
7	Equulus. N.	316	5 N.
43	Equuleus Pictorius. S.	84	55 S.
2	Eridanus. S	60	10 S.
11	Fornax Chymica. S.	42	30 S.
3	Gemini. Z.	111	32 N.
32	Grus. S.	330	45 S.
13	Hercules. N.	255	22 N.
37	Horologium. S.	40	60 S.
6	Hydra. S.	139	8 S.
39	Hidrus. S	28	68 S.
31	Indus. S.	315	55 S.
28	Lacerta. N.	33	43 N.
5	Leo Major. Z.	150	15 N.
8	Leo Minor. N.	150	35 N.
13	Lepus. S.	80	18 S.
7	Libra. Z.	226	8 S.
21	Lupus. S.	230	45 S.
34	Lynx. N.	111	50 N.
14	Lyra. N.	283	38 N.
17	Machina Pneumatica. S. . .	150	32 S.
8	Microscopium S.	315	35 S.
4	Monoceros. S.	110	0
1	Mons Mænalus. N.	225	5 N.
41	Mons Mensæ. S.	76	72 S.
22	Musca. N.	40	27 N.
26	Musca Australis, vel Apis. S. .	185	68 S.
22	Norma, vel Quadra Euclidis. S. .	242	45 S.
35	Octans Hadleianus. S.	310	80 S.
10	Officina Sculptoria. S. . . .	3	38 S.
3	Orion. S.	80	0
33	Pavo. S.	302	68 S.
18	Pegasus N.	340	14. N.

		Right Ascen.	Declin.
31	Perseus. N.	46	49 N.
36	Phœnix. S.	10	50 S.
12	Pisces. Z.	5	10 N.
9	Piscis Notus, vel Australis. S.	335	30 S.
46	Piscis Volans. S.	127	68 S.
42	Praxiteles, vel Cela Sculptoria. S.	68	40 S.
16	Pyxis Nautica. S.	130	30 S.
38	Reticulus Rhomboidalis. S.	62	26 S.
47	Robur Caroli. S.	159	50 S.
9	Sagittarius. Z.	285	35 S.
16	Sagitta. N.	295	18 N.
7	Sextans. S.	5	0
8	Scorpio. Z.	244	26 S.
5	Scutum Sobieski. N.	275	10 S.
2	Serpens. N.	235	10 N.
3	Serpentarius. S.	260	13 N.
2	Taurus. Z.	65	61 N.
4	Taurus Poniatowski. N.	275	7 N.
29	Telescopium. S.	278	50 S.
40	Toucan. S.	359	66 S.
20	Triangulum. N.	27	32 N.
24	Triangulum Australe. S.	238	65 S.
21	Triangulum Minus. N.	32	28 N.
24	Ursa Major. N.	153	60 N.
23	Ursa Minor. N.	235	75 N.
6	Virgo. Z.	195	5 N.
15	Vulpecula et Anser. N.	300	25 N.
44	Xiphias. S.	75	62 S.

NOTE. The figures in the left hand column point to the numbers in the foregoing table where the English name is given.

Problems performed by the Celestial Globe.

PROBLEM I.

To find the latitude and longitude of a star.

RULE. Bring the pole of the ecliptic to the brass meridian; place the upper end of the quadrant of altitude over that pole of the ecliptic nearest the star; move the other end of the quadrant until its graduated edge is brought to the star; then the number of degrees on the quadrant between the ecliptic and the star, is its latitude; and the number of degrees on the ecliptic between the first degree of Aries and the quadrant, reckoning according to the signs eastward, is its longitude.

1. Required the latitude and longitude of Aldebaran in the eye of Taurus.

Ans. 5° 28′ south latitude, and 2 signs 6° 53′ longitude.

2. Required the latitude and longitude of
   Arcturus in Bootes,
   Pollux in Gemini,
   Procyon in Canis Minor,
   Argol in Perseus,
   Rastaben in Draco.
   Vega in Lyra,
   Antares in Scorpio,
   Altair in Aquila,
   Fomalhaut in the Southern Fish,
   Markab in Pegasus,
   Deneb in Cygnus

OBS. The longitude of the sun, a star or planet, is reckoned on the ecliptic from the point Aries, eastward quite round the globe.

PROBLEM II.

To find the declination and right ascension of a star.

RULE. Bring the given star to the brass meridian, and the degree above it will be its declination; and the number of degrees on the equinoctial between the brass meridian and the point Aries, will be its right ascension.

1. Required the declination and right ascension of Dubhe in the back of the Great Bear.

Ans. Its declination is 62° 48′ north; and its right ascension 162° 49′.

2. Required the declination and right ascension of
   Mirach in Andromeda,
   Algol in Perseus,
   Aldebaran in Taurus,
   Arcturus in Bootes,
   Procyon in the Little Dog,
   Vega in Lyra,
   Pollux in Gemini,
   Rastaben in Draco,
   Rigel in Orion,
   Antares in Scorpio,
   Canopus in Argo Navis,
   Menkar in Cetus,
   Algorab in the Crow.

OBS. The degree of the equinoctial that comes to the meridian with the sun, planet, or star, reckoning from the first degree of Aries, is its right ascension.

The distance of the sun, star, or planet, in degrees from the equinoctial towards either pole, north or south, is its declination.

PROBLEM III.

To find the declination and right ascension of the sun or a planet on any given day in the year.

Rule. 1. Find the sun's place in the ecliptic; bring it to the brass meridian, and the degree over it will be his declination; and the distance in degrees, from the brass meridian to the point Aries, will be his right ascension.

2. *For a planet.* Find in the nautical almanac, or some good ephemeris, the planet's geocentric place in the ecliptic for the given day, and mark it with a soft lead pencil on the globe; bring it to the brass meridian, and the degree over it, will be its declination; and the distance from the brass meridian to the point Aries, will be its right ascension.

1. Required the right ascension and declination of the sun on the 1st of January.
2. Required the declination and right ascension of the sun on the 14th of February.
3. Required the declination and right ascension of Venus on the 20th of March.
4. Required the declination and right ascension of Mars on the 7th of April.
5. Required the right ascension and declination of the moon on the 4th of May.
6. Required the declination and right ascension of Jupiter on the 1st of June.
7. Required the declination and right ascension of Saturn on the 4th of July.
8. Required the right ascension and declination of Herschel on the 16th of August.

PROBLEM IV.

Given the latitude and longitude of a star or planet, to find its place on the globe.

RULE. Place that part of the quadrant of altitude marked 0, on the given longitude in the ecliptic, and the upper end over the pole of the ecliptic; and under the given latitude will be found the star, or the planet's place required.

1. Required that star having 6° 19′ longitude, and 12° 36′ north latitude.

2. When the longitude of the moon is 5 signs 16° 8′, and its latitude 2° 61′ north; required its place on the globe.

3. Required those stars having the following latitudes and longitudes,

Latitudes.	Longitudes.
16° 3′ S.	2s. 25° 51′
22 52 N.	2 18 57
31 8 S.	4 13 56
10 4 N.	3 17 21
44 20 N.	7 9 22
27 N.	4 26 67

4. When the longitude of Mercury is 1s. 19° 42′, and its latitude 2° 20′ south; required its place on the globe.

5. The longitude of Venus being 2s. 12° 26′, and the latitude nothing; required its place on the globe.

6. The longitude of Mars being 10s. 7° 35′, and its latitude 2° 59′; required its place on the globe.

7. When the longitude of Jupiter is 4s. 5° 19′ S.

and its latitude 42′ north; required its place on the globe.

8. The longitude of Saturn being 9s. 18° 30′, and its latitude 21′ north; required its place on the globe.

9. When the longitude of Herschel is 7s. 25° 20′, and its latitude 14′ north; required its place on the globe.

PROBLEM V.

Given the declination and right ascension of a star or planet, to find its place on the globe.

RULE. Bring the given degree of right ascension to the brass meridian; and under the given degree of declination will be the star, or planet's place required.

1. Required that star whose declination is 52° 27′ north, and right ascension 261° 29′.

Ans. Above the left foot of Castor in the milky-way.

2. When the moon's right ascension is 91° 3′, and its declination 24° 48′; required its place on the globe.

3. Required those stars having the following right ascension and declination,

Right ascension.	Declination.
46° 32′	9° 34′ S.
76 14	8 27 S.
25 54	19 50 N.
7 19	55 26 N.
100 27	32 19 N.
86 13	44 55 N.
99 5	16 26 S.

4. The declination of Venus being 11° 41′ north, and its right ascension 31° 30′; required its place on the globe.

5. The moon's right ascension at midnight being 352° 21′, and its declination 17° 25′ south; required its place on the globe.

6. The right ascension of Jupiter being 138°, and its declination 10° 29′ south; required its place on the globe.

PROBLEM VI.

To find the distance between any two given stars in degrees.

Rule. Lay the quadrant of altitude over the two given stars; and the number of degrees between them, reckoned on the quadrant, will be their distance as seen from the earth. Or, extend a thread over any two given stars; apply the distance found to the equator, and count the number of degrees.

1. Required the distance between Altair in the Eagle, and Vega in Lyra.

Ans. 35 degrees.

2. Required the distance between Arcturus in Bootes, and Procyon in the Little Dog.

3. What is the distance between Argol in Perseus, and Aldebaran in Taurus?

4. Required the distance between Vega in Lyra, and Rastaben in Draco.

5. What is the distance between Pollux in Gemini, and Altair in the Eagle?

6. Required the distance between Rigel in Orion, and Algorab in the Crow.

PROBLEM VII.

Given the latitude of the place, and day of the month, to find the meridian altitude of any star or planet.

RULE. 1. Elevate the pole as many degrees above the horizon, as are equal to the latitude of the place.

2. *For a star.* Bring the given star to the brass meridian, and the number of degrees on the meridian between the star and the horizon, will be its meridian altitude.

3. *For a planet.* Look in the Nautical Almanac, or an ephemeris, for the planet's right ascension and declination for the given day, and mark its place on the globe with a soft lead pencil; bring the planet's place to the brass meridian, and the number of degrees between it and the horizon, will be its meridian altitude.

1. Required the meridian altitude of Arcturus in Bootes at London.

2. Required the meridian altitude of Algol in Perseus at Boston.

3. What is the meridian altitude of Aldebaran at New-York?

4. Required the meridian altitude of Rastaben in Draco at Quebec.

5. Required the meridian altitude of Venus at Washington on the 22d of May.

6 On the 1st of May, 1824, the right ascension of Venus 31° 31′ north; and its declination 11° 41′ north; required the meridian altitude.

7. Supposing on the 4th of July at Philadelphia, the declination of Jupiter is 19° 29′ south, and its right ascension 238°; required its meridian altitude.

Obs. 1. The number of degrees that the star or planet is above the horizon, as observed by means of a common quadrant, is called its altitude.

2. The degrees of altitude must be counted from the star &c. towards the pole, which is depressed below the horizon.

PROBLEM VIII.

Given the latitude of the place, the day, and hour, to place the globe so as to represent the appearance of the heavens, and to point out the situations of the several stars.

Rule. Elevate the pole as many degrees above the horizon as are equal to the latitude of the place; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index of the hour circle at 12; if the time be past noon, turn the globe westward; if the given time be before noon, turn the globe eastward, until the index points to the given hour, and the surface of the globe will then represent the appearance of the heavens at that place.

1. Place the globe so as to represent the appearance of the heavens at New-York, on the 1st of January, at 10 o'clock in the evening.

2. At Boston, August 14, at 8 o'clock in the morning.

3. At London, on the 30th of March, at 9 o'clock in the evening.

4. At Oporto, on the 17th of April, at midnight.

5. At St. Petersburg, on the the 30th of May, at 6 o'clock in the evening.

6. At Edinburgh, on the 4th of July, at 7 o'clock in the morning.

7. At Washington, on the 22d of May, at 10 o'clock in the evening.

8. At Paris, on the 16th of September, at 2 o'clock in the morning.

PROBLEM IX.

Given, two stars, one on the meridian, and the other in the east or the west point of the horizon, to find the latitude of the place.

RULE. Bring the star observed to be on the meridian, to the brass meridian; elevate or depress the pole until the other star comes to the eastern or the western point of the horizon, observing to keep the globe from turning on its axis; and the number of degrees from the elevated pole to the horizon, will be the latitude required.

1. The two pointers in the Great Bear, Dubhe and β, being observed to be on the meridian, Vega in Lyra to be rising; required the latitude.
Ans. 27° north.

2. Arcturus in Bootes being observed to be on the meridian, and Altair in the Eagle, to be rising; required the latitude.

PROBLEM X.

Given, the day of the month, to find at what hour any given star comes to the meridian.

Rule. Bring the sun's place in the ecliptic to the brass meridian, and set the index of the hour circle at the upper 12; turn the globe westward until the given star comes to the brass meridian, and the number of hours passed over, will be the time from noon, when the star culminates.

1. At what hour does Arcturus come to the meridian of London, on the 9th of February.

Ans. At half past 4 o'clock in the morning.

2. Required the time at which the following stars come to the meridian of Washington,

Aldebaran on the 12th of January.
Menkar on the 5th of November.
Antares on the 24th of February.
Regulus on the 4th of July,
Rastaben on the 16th of September.
Fomalhaut on the 14th of June.

PROBLEM XI.

Given, the day of the month at any place, to find when a star or planet will rise, come to the meridian, and set.

Rule. Elevate the pole as many degrees above the horizon, as are equal to the latitude of the place; find the sun's place in the ecliptic;

bring it to the meridian, and set the index of the hour circle at 12: turn the globe westward until the star or planet comes to the eastern edge of the horizon, and the index will point to the hour of its rising from noon—continue this motion of the globe westward until the star or planet is brought to the brass meridian, and the index will point to the hour of its culmination—let the globe be turned westward until the star or planet's place arrives at the western edge of the horizon, and the index will show the time of the sun's setting from noon.

1. At what time does Aldebaran rise, culminate, and set at New-York, on the 1st of January?

2. Required at what time Sirius rises, comes to the meridian, and sets on the 4th of March, at Boston.

3. Required at what time Arcturus rises, culminates, and sets at Washington city, on the 22d of May.

4. Required at what time Fomalhaut rises, culminates, and sets at Vienna, on the 14th of June.

5. The longitude of Jupiter being 7s. 26° 34′; and its latitude 45 minutes north; at what time does it rise, culminate, and set, at London the 4th of July.

6. When the longitude of Mars is 8 signs 3 degrees 20 minutes and its latitude 36 minutes north; required the time of its rising, culminating, and setting at Paris, on the 20th of September.

7. When the longitude of Venus is 8s. 5° 55′; and its latitude 1° 41′ north; at what time does it rise, culminate, and set, on the 9th of December, at Oporto.

PROBLEM XII.

Given, the latitude of a place, to find the amplitude of any known star, its oblique ascension and descension, its ascensional difference, and the time of its continuance above the horizon.

Rule. Rectify the globe for the latitude of the place, and bring the given star to the eastern edge of the horizon; the number of degrees between the star and the east point of the horizon, will be its rising amplitude, and the degree on the equinoctial, cut by the horizon, will be its oblique ascension. Keep the globe in this position, and set the index of the hour circle to 12; turn it west ward, until the given star is brought to the brass meridian, and the number of hours passed over by the index, will be the star's semidiurnal arc, or half the time of its continuance above the horizon.

The degree on the equinoctial, cut by the brass meridian, will be the star's right ascension; the difference between which and the oblique ascension, is the ascensional difference. Continue the motion of the globe westward, until the star is brought to the western edge of the horizon, and find the setting amplitude and oblique descension as above.

1. At New-York, required the rising and setting amplitude of Procyon, its oblique ascension and descension, diurnal arc, and ascensional difference.

Ans. Its rising amplitude north of the east point is 7°; its setting amplitude north of west is 7°; oblique ascension, 107¼°; oblique descension, 117°; right ascension, 112°; ascensional difference, 5°; and its continuance above the horizon, 12 hours 40 minutes.

2. At Washington, required the rising and setting amplitude of Aldebaran, its oblique ascension and descension, diurnal arc, and ascensional difference.

3. At Boston, required the rising and setting amplitude of Arcturus, its oblique ascension and descension, diurnal arc, and ascensional difference.

4. At Philadelphia, required the rising and setting amplitude of Sirius, its oblique ascension and descension, diurnal arc, and ascensional difference.

PROBLEM XIII.

The latitude of the place, day of the month, and hour of the day, being given, to find the altitude and azimuth of any known star.

Rule. Elevate the pole to the latitude of the place, screw the quadrant in the zenith, bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle at 12; if the given time be in the morning, turn the globe eastward, but if in the evening, turn it westward, as many hours as the time is before or after noon; keep the globe in this position, move the quadrant of altitude until its graduated edge is brought to the centre of the given star; the number of degrees on the quadrant between the horizon and the star, is its altitude; and the degree on the horizon, cut by the quadrant, will be its azimuth, reckoning from north or south.

1. When it is 5 o'clock in the morning, on the

23d of September, at Philadelphia, required the altitude and azimuth of α, Arietis.

Ans. Its altitude is 47°, and azimuth 78½°, from the south towards the west.

2. When it is 9 o'clock in the evening at London, on the the 10th of February, required the altitude and azimuth of Sirius.

3 When it is 10 o'clock in the morning at Washington, on the 4th of July, required the altitude and azimuth of Procyon.

4. When it is 6 o'clock in the evening at Paris, on the 14th of August, required the altitude and azimuth of Altair in the Eagle.

5. When it is 11 o'clock in the evening at Edinburgh, on the 18th of March, required the altitude and azimuth of Arcturus.

6. When it is 10 o'clock in the morning, at Vienna, on the 17th of January, required the altitude and azimuth of Lyra in the Harp.

PROBLEM XIV.

To ascertain the day of the year on which any known star will be upon the meridian at a given hour.

Rule. Bring the star to the brass meridian, and set the index of the hour circle at 12; turn the globe on its axis westward or eastward, according as the given time is in the morning or evening, as many hours as the time is from noon; and the brass meridian will cross the ecliptic in the degree of the sun's place, corresponding to the time in the circle of months on the horizon.

1. On what day of the year will Regulus in Leo be on the meridian of Philadelphia, at 9 o'clock in the evening?

Ans. The time being 9 hours after noon, the globe must be turned eastward until the index shall have passed over 9 hours; the meridian will intersect the ecliptic, in 15° of Aries, which will correspond to the 5th of April.

2. On what day of the year will Arcturus be on the meridian of New-York, at 10 o'clock in the morning?

3. On what day of the year will Sirius be on the meridian of Washington, at 8 o'clock in the evening?

4. On what day of the year will Procyon be on the meridian of St. Petersburg, at 11 o'clock in the morning?

5. On what day of the year will Lyra in the Harp be on the meridian of London, at 7 o'clock in the evening?

6. On what day of the year will Altair in the Eagle be on the meridian of Madrid, at 6 o'clock in the morning?

Obs. When the time is in the morning, or before noon, the globe must be turned westward; but when the time is after noon, it must be turned eastward.

PROBLEM XV.

Given, the latitude, day of the month, and two stars having the same azimuth, to ascertain the hour of the night.

Rule. Rectify the globe for the latitude, screw the quadrant of altitude in the zenith, bring the

sun's place in the ecliptic to the brass meridian, and set the index of the hour circle at 12; turn the globe westward until the two stars coincide with the graduated edge of the quadrant of altitude, and the number of hours passed over, will be the time from noon. The azimuth of the given stars will be found on the horizon.

1. At New-York, on the 22d of September, at what hour will Capella in Auriga, and Castor in Gemini, have the same azimuth, and what will their azimuth be at that hour?

Ans. Before the stars coincide with the quadrant, the index will have passed over 13¼ hours from noon; consequently it will be a quarter past one; and the azimuth from the north towards the east will be 63 degrees.

2. At London, on the 1st May, at what hour will Altair and Vega have the same azimuth, and what will be their azimuth?

3. At Paris, on the 20th of April, at what hour will Spica Virginis and Arcturus have the same azimuth, and what is that azimuth?

4. At Rome, on the 4th of July, at what hour will Sirius and Rigel have the same azimuth, and what will their azimuth be?

PROBLEM XVI.

The day of the month, and the hour when a given star rises or sets, being given, to find the latitude of the place.

Rule. Find the sun's place in the ecliptic for the given day, bring it to the brass meridian, and

set the index of the hour circle at 12; turn the globe on its axis eastward or westward, according as the given time is in the morning or evening, as many hours as the time is from noon; elevate or depress the pole until the star is level with the horizon, and the number of degrees that the pole is elevated above the horizon, will equal the latitude required.

1. On the 10th of May, in what latitude does Altair rise at 10 o'clock in the evening?

Ans. 41° 35′.

2. On the 14th of July, in what latitude does Dubhe in the Great Bear rise, at 8 o'clock in the morning?

3. On the 20th of August, in what latitude does Capella rise, at 9 o'clock in the evening?

4. In what latitude does Acubens rise, at 4 o'clock in the morning, on the 17th of September?

5. In what latitude does Antares in Scorpio rise, at 2 o'clock in the morning, on the 24th of November?

6. In what latitude does Achernar set, at 10 o'clock in the morning, on the 28th of December?

PROBLEM XVII.

Given, the latitude, day of the month, and two stars having the same altitude, to find the hour of the night.

Rule. Rectify the globe for the latitude, zenith, and sun's place; turn it on its axis westward until the given stars coincide with the given alti-

tude on the quadrant, or until they are at the same distance from the horizon, if the altitudes be not given; the hours passed over by the index, will be the time from noon, when the stars will have that altitude.

1. Required the hour on the 10th of July, at New-York, when Castor in Gemini, and Betelguese in Orion, have each 5° of altitude.

Ans. At a quarter past 4 in the morning.

2. Required the hour on the 18th of January, at Constantinople, when Fomalhaut in the Southern Fish, and Altair in the Eagle, have each 12° of altitude.

3. Required the hour on the 22d of May, at Boston, when Algol in Perseus, and Aldebaran, have each 17° of altitude.

4. Required the hour on the 31st of August, at Greenwich, when *a* in the head of Andromeda, and Menkar in Pegasus, have each 30° of altitude.

PROBLEM XVIII.

Given, the latitude of the place, to find the time of the year when any given star rises or sets cosmically, or when it rises or sets at sunrising.

RULE. Rectify the globe for the latitude, bring the star to the eastern semicircle of the horizon, and the day of the month, corresponding with the degree on the ecliptic, cut by the upper edge of the horizon, will give the time of the star's rising with the sun; bring the star to the western semicircle of the horizon, the sign and degree of the ecliptic then intersected by the eastern edge of the

horizon as before, will show on the horizon the time when the star sets cosmically.

1. Required the time of the year when the Pleiades rise and set cosmically in latitude 37° north.

Ans. They rise with the sun on the 11th of May, and set at the time of sunrising on the 21st of November.

2. Required the time of the year when Regulus rises and sets cosmically at New-York.

3. Required the time of the year when Procyon rises and sets cosmically at London.

4. Required the time of the year when Antares rises and sets cosmically at St. Petersburg.

5. Required the time of the year when Vega rises and sets cosmically at Washington.

6. Required the time of the year when Sirius rises and sets cosmically at Canton.

PROBLEM XIX.

To find the time of the year, when a star rises or sets heliacally, that is, when it first emerges from the solar rays in the morning, or disappears by falling into the solar rays in the evening.

Rule. Elevate the pole to the latitude of the place, screw the quadrant of altitude in the zenith, turn the globe, and move the quadrant till the given star is found by it, to be 12° above the eastern edge of the horizon, if the star is of the 1st magnitude; 13° if of the 2d; 14° if of the 3d, &c. The point of the ecliptic, intersected by the eastern edge of the horizon, will agree with the day of the month, on which the star will rise heliacally.

Turn the globe westward, till the star is found, by the quadrant to be 12°, 13°, &c. above the western edge of the horizon, and the point of the ecliptic then intersected by the same edge of the horizon, will direct, as before, to the time of the star's setting heliacally.

1. Required the time of the year when Sirius rises and sets heliacally, in latitude 31° $11\frac{1}{4}'$ north.
Ans. On the 4th of August, and the 23d of May.

2. Required the time of the year when Aldebaran rises and sets heliacally at Paris.
3. Required the time of the year when Arcturus rises and sets heliacally at Stockholm.
4. Required the time of the year when Menkar rises and sets heliacally at Vienna.

PROBLEM XX.

Given, the latitude of the place, to find the time of the year when any known star rises or sets achronically, i. e. when it rises or sets at sunsetting.

Rule. Rectify the globe for the latitude of the place, bring the given star to the eastern semicircle of the horizon, and mark the point of the ecliptic, that is cut by the western edge of the horizon, or that sets when the star rises; the day of the month, corresponding with this point, will give the time when a star rises at sunset, or when it is first visible in the evening; after which, turn the globe westward on its axis until the star is brought to the western part of the horizon, observe the degree on the ecliptic, cut by the western edge

of the horizon as before, and the day of the month, corresponding to the degree, will show the time when the star sets with the sun.

1. Required the time when Arcturus rises and sets achronically, in latitude 37° 45′ north.

Ans. The 12th degree of Aries will be at the western edge of the horizon, when Arcturus is in the eastern, which corresponds with the 1st of April, the time of its rising; and the time of its setting is on the 30th of November.

2. Required the time when Capella rises and sets achronically at New-Orleans.

3. Required the time when Antares rises and sets achronically at New-York.

4. Required the time when Aldebaran rises and sets achronically at London.

5. Required the time when Acubens rises and sets achronically at Vienna.

6. Required the time when Vega rises and sets achronically at St. Petersburg.

PROBLEM XXI.

Given, the latitude of the place, and day of the month, to find all those stars that rise and set cosmically, heliacally, and achronically.

Rule. 1. After rectifying the globe for the latitude, bring the sun's place to the eastern edge of the horizon, and all those stars along the eastern semicircle of the horizon, will *rise* cosmically, and those along the western semicircle, will *set* cosmically.

2. Screw the quadrant of altitude in the zenith,

turn the globe eastward on its axis until the sun's place cuts the quadrant 12° below the horizon, and all the stars of the first magnitude along the eastern semicircle of the horizon, will rise heliacally. By turning the globe eastward until the sun's place intersects the quadrant in 13°, 14°, 15°, 16°, &c., below the horizon, will be found all the stars of the 2d, 3d, 4th, 5th, &c. magnitudes, which rise heliacally on that day. Turn the globe westward, bring the quadrant to the western semicircle of the horizon, and proceed as above, and you will have all those stars that set heliacally on that day.

3. Bring the sun's place in the ecliptic to the western semicircle of the horizon; all the stars along the eastern part will rise, and all along the western part will set achronically.

1. Required those stars that rise and set cosmically, heliacally, and achronically, at New-York, on the 4th of December.

Ans. 1. Antares will be near the eastern semicircle of the horizon; and will consequently rise cosmically nearly;—and Algol will set cosmically. 2. Arided in Cygnus will rise heliacally; and β in Serpens will set heliacally, &c. 3. Aldebaran, &c. will rise achronically; and Arcturus, &c., will set achronically.

2. Required those stars that rise and set cosmically at London, on the 4th of September.

3. Required those stars that rise and set heliacally at Philadelphia, on the 17th of January.

4. Required those stars that rise and set achronically at Moscow, on the 20th of March.

5. Required those stars that rise and set cosmically, heliacally, and achronically, at Amsterdam, on the 16th of April.

6. Required those stars that rise and set cosmically, heliacally, and achronically, at Edinburgh, on the 24th of May.

Obs. This problem is the reverse of the three foregoing.

The achronical, cosmical, and heliacal rising and setting of stars, were terms used only by the ancient poets, and consequently the principal use of these four problems is to illustrate some passages in their writings.

PROBLEM XXII.

Given the latitude of the place, day of the month, and azimuth of a known star, to find the hour of the night and altitude of the star.

Rule. Rectify the globe for the latitude of the place, bring the sun's place to the meridain, screw the quadrant of altitude in the zenith, and set the index of the hour circle to the upper 12; place the graduated edge of the quadrant opposite the given degree of azimuth on the horizon; turn the globe westward until the star is brought to the edge of the quadrant; the number of hours passed over by the index, will be the time from noon; and the number of degrees on the quadrant between the star and the horizon, will be the altitude required.

1. Required at what time from noon, at London, on the 28th of December, the azimuth of Deneb in Leo, marked β, is $62\frac{1}{2}$ degrees from the south towards the west, and the star's altitude.

Ans. In turning the globe, the index of the hour circle will pass over 19 hours and 45 minutes from noon; consequently it is 45 minutes past 7 in the morning. The star's altitude is $32\frac{1}{2}$ degrees.

2. At New-York, on the 21st of June, when the azimuth of Altair is 83°23′ from the south towards the east, required the time of night and the star's altitude.

Ans. It will be 9 o'clock in the evening, and the star's altitude will be 20° 22′.

3. At Philadelphia, on the 23d September, the azimuth of Arietis being 79° from the south, required the hour of the night, and the star's altitude.

4. At London, on the 5th of May, the azimuth of Regulus, marked *a*, being 74 degrees from the south towards the west, required the hour of the night, and the star's altitude.

PROBLEM XXIII.

Given, the latitude of the place, day of the month, and the altitude of a given star, to find the hour of the night and the star's azimuth.

Rule. Elevate the pole to the latitude, screw the quadrant of altitude in the zenith, bring the sun's place to the brass meridian, and set the index of the hour circle at the upper 12; bring the quadrant of altitude to that side of the brass meridian, on which the star was situated when observed; turn the globe westward until the centre of the star cuts the given degree of altitude on the quadrant; the hours passed over by the index, will be the time from noon when the star has that altitude, and the degree where the quadrant intersects the horizon, will be the azimuth required.

1. At Philadelphia, on the 23d of September, the altitude of Arietis being observed to be 47°,

and west of the meridian; required the hour and the star's azimuth.

Ans. In turning the globe westward, until the star intersects the quadrant west of the meridian at the given degree of altitude, the index will pass over 17 hours, which will make the time 5 o'clock in the morning. The azimuth from the south towards the west will be 79 degrees.

2. At London, on the 28th of December, the altitude of Deneb being observed to be 40 degrees, and east of the meridian; required the hour, and the star's azimuth.

3. At Washington, on the 21st of March, the altitude of Lyra being observed to be 50 degrees, and east of the meridian; required the hour, and the star's azimuth.

PROBLEM XXIV.

Having the meridian altitude of the sun, star, or planet given, to find the latitude of the place where the altitude was observed.

Rule. Bring the given star, the place of the sun or planet, to the brass meridian, and mark the degree over it; count from the marked degree on the brass meridian, northward or southward, as the sun, &c. may be north or south of the observer, as many degrees as are equal to the given meridian altitude; then bring the degree where the reckoning ends to the horizon, and the elevation of the pole will be equal to the latitude.

1. Required the latitude of that place where the sun's meridian altitude is 58° 17′, on the 17th of May, the sun being north of the observer.

Ans. The sun's place, 26° 40′ of Taurus, being

brought to the meridian, will be under 19° 20′; count from this degree towards the north pole 58° 17′, and the reckoning will end at 77° 37′; depress the north pole until this point is brought to the horizon, and the south pole will be elevated equal to the latitude, which will be 12° 23′ south.

2. On the 13th of August, 1825, Jupiter's meridian altitude being observed to be at the southward 46° 36′; required the latitude of the place of observation.

Ans. The longitude of Jupiter is 4s. 23° 31′, and his latitude 0° 47′ north, as given in the Nautical Almanac; the planet's place being brought to the meridian, the degrees and minutes over it will be 14° 27′; count 46° 36′ from this point of the meridian towards the south pole, and the reckoning will end at 32° 9′ south; then depress the south pole until 32° 9′ is brought to the horizon, and the north pole will be elevated to the latitude, which will be 57° 51′ north.

3. Being at sea, the meridian altitude of the star Capella north of the place of observation being found to be 76° 48′, required the latitude of the ship.

Ans. 32° 36′ north.

PROBLEM XXV.

Given the altitudes of two stars, at the same instant, to find the latitude of the place.

Rule. Take a pair of compasses, fasten a black lead pencil in one foot, and open them to an extent equal to the complement of the altitude of one star; then place one foot of the compasses in that star, and sweep an arc with the pencil; then with one foot of the compasses in the other star,

with the extent of the complement of the other star's altitude, describe another arc that will intersect the former; bring the point of intersection, (which will always be in the zenith,) to the brass meridian, and the degree over it will be the latitude required.

The extent of the complements of altitude, may be taken from the equinoctial.

1. The altitude of Aldebaran being observed to be 51° 45′, and that of Castor to be 76° 40′; required the latitude of the place.

Solution. 51° 45′ being subtracted from 90°, gives the complement 38° 15′—then with an extent of 38¼° taken from the equinoctial, and one foot of the dividers in the centre of Aldebaran, sweep an arc towards the north; then 90°—76° 40′=13° 20′, with 13° 20′ in the compasses, and one foot in the centre of Castor, sweep another arc intersecting the former; this point of intersection being brought to the brass meridian, will be under 42° north latitude.

2. The altitude of Procyon in north latitude being observed 50°, and that of Betelguese in Orion to be at the same time 58°; required the latitude of the place.

3. Required the latitude of the place where the altitude of Markab in Pegasus is 30°, and that of Altair in the Eagle is 65° at the same time.

4. Being at sea, in north latitude, the altitude of Capella was observed to be 30°, and that of Aldebaran at the same time 35°; required the latitude.

PROBLEM XXVI.

To illustrate the precession of the equinoxes.

Rule. Elevate the north pole 90° above the horizon, and the equinoctial will be level with the

horizon; bring the pole of the ecliptic to that side of the brass meridian, which is numbered from the pole towards the equator, and mark the degree above it—this mark must be considered as the pole of the world; the equinoctial will then represent the ecliptic, and the ecliptic will represent the equinoctial. Then turn the globe gradually on its axis from east to west, and the equinoctial points will move the same way, and describe a revolution around the globe in the same time that the pole of the world, represented by the pole of the ecliptic, will describe a circle of 46° 56′ in diameter around the pole of the ecliptic, which is represented by the pole of the world.

This circle will be completed in 25,791 years, called a Platonic year. Thus the pole of the heavens will vary its situation, or appear to move backward $50\frac{1}{4}$ seconds every year. If from the above-mentioned mark on the meridian, the complement of the latitude be reckoned upwards, the mark where the reckoning ends, will be exactly over the latitude. Thus, the latitude of New-York will be 64° 11′ on the brass meridian, reckoning from the southern point of the horizon, or from the equator.

Obs. All the stars in the different constellations continually increase in longitude; consequently, either the whole starry heavens have a slow motion from west to east, or the equinoctial points have a slow motion from east to west. In the time of Meton, a famous mathematician of Athens, who flourished about 430 years before Christ, the star marked β, Arietis, in the constellation Aries, passed through the vernal equinox, whereas it is now upward of 30° to the westward of it.

Promiscuous Exercises

ON

THE GLOBES.

1. Required the latitude and longitude of New-York, Philadelphia, Washington, New-Orleans, Savannah, Pekin, Nankin, London, Edinburgh, Dublin, Paris, Marseilles, Lisbon, Madrid, Oporto, Vienna, Warsaw, Moscow, St. Petersburg, Stockholm, Buenos Ayres, Lima, Havanna, Porto Rico, Archangel, Astrachan, Jerusalem, Constantinople, Rome, Algiers, Morocco, Tunis, Cairo, Barcelona, Liverpool, and Glasgow.

2. Required the distance in English and geographical miles, between Cape Verd and Cape St. Roque, London and New-York, Washington and Paris, St. Petersburg and Edinburgh, Boston and Charleston, Portland and Mobile, and between the northern extremity of Scotland and the southern extremity of England, the northern and southern, eastern and western extremities of England, Scotland, Ireland, France, Spain, Germany, Italy, Turkey, Russia, Prussia, Austria, Sweden, and Denmark; the northern and southern, eastern and western extremities of Europe, Asia, Africa, America, and New-Holland.

3. Required the sun's declination at Washington city, on the 1st of January; 2d of February; 3d of March; 4th of April; 5th of May; 6th of June; 7th of July; 8th of August; 9th of Septem-

ber; 10th of October; 11th of November; 12th of December.

4. When it is 12 o'clock at London, what time is it at Boston? Charleston? New-Orleans? the mouth of the Oregon or Columbia river? Sandwich Islands? New Hebrides? Botany Bay? Batavia? Calcutta? Alexandria? Cape St. Vincent?

5. When it is 9 o'clock in the morning at Washington city, what time is it at London?

6. At what hour does the sun make his first appearance at NewYork, on the 1st of January? 1st of February? 1st of March? 1st of April? 1st of May? 1st of June? 1st of July? 1st of August? 1st of September? 1st of October? 1st of November? and 1st of December?

7. At what hour does the sun set on the first day of every month in the year?

8. Required the length of the first day of every month in the year.

9. Required the length of the longest day at Quito; New-Orleans; London; St. Petersburg; Archangel; the north pole.

10. At what time does the sun rise and set at New-York, on the 4th of July?

11. At what time does the sun rise and set at Boston, on the 14th of December?

12. How many miles make a degree of longitude in the latitude of New-York?

13. What day of the year is of the same length as the 14th of August.

14. At what hour is the sun due east at Quebec, on the 1st of June?

15. Required the equation of time depending on the obliquity of the ecliptic, on the 14th of January.

16. What is the elevation of the north polar

star above the horizon at New-Orleans when it is of the same height as the pole?

17. Required the sun's altitude at 4 o'clock in the evening at Boston, on the 22d of June.

18. Required the length of the day at Paris, on the 4th of July.

19. Required the hour on the 17th of October, when Arcturus is 30° above the horizon of St. John's, and eastward of the meridian.

20. At what hour does the sun make his first appearance at Boston, on the 17th of April?

21. At what hour does the sun set at Washington, on the 4th of January?

22. Does the sun shine over the north pole or the south, on the 14th of December?

23. Are the clocks at Washington city faster, or slower, than at London? and how much?

24. Required the difference of latitude between St. Petersburg and Lima.

25. What stars are constantly above the horizon at Washington city?

26. Are the clocks at Canton faster, or slower, than at Madrid? and how much?

27. The longitude of a planet being 9s. 29° 2′, and its latitude 14 minutes south, on the 20th of May, required whether it will rise before or after the sun, and how much?

28. When the longitude of Jupiter is 5s. 3° 41′; and its latitude 52 minutes north, September 30th, 1825; required at what time it will rise, come to the meridian, and set at Baltimore.

29. When the moon's longitude is 9° 21′, and its latitude 4° 31′ south; what is its rising and setting amplitude at London?

30. When Arcturus rises at 8 o'clock in the evening, required the latitude.

31. In what latitude is the longest day 8 hours in length?

32. Required the antipodes of New-York.

33. At what time does the morning twilight begin, and at what time does the evening twilight end, at Baltimore, on the 21st of June?

34. Required the distance between London and New-York in English miles.

35. At the time of the summer solstice at Lisbon, at what time is the sun due east?

36. At what hour at London is the sun due east, at the time of the equinoxes?

37. Required those places having the same hour of the day as Portland.

38. When the sun is vertical at Havanna on the 10th of June, where is it midnight?

39. How long will the sun shine without setting at the north pole?

40. Required those degrees of the ecliptic and equinoctial, that rise with Aldebaran at London.

41. On what day of the year will Regulus come to the meridian at midnight?

42. At London the sun's altitude being observed to be 25° 30′, when on the prime vertical, required his declination, and the hour of the day.

43. Required the sun's right ascension at Philadelphia, at the time of the equinoxes.

44. The sun's rising amplitude being 24° northward of the east point, on the 20th of May, required the latitude of the place.

45. Required the length of the day on the 14th of July, at Washington.

46. Required the hour at Rome, when it is 5 o'clock in the morning at Boston.

47. Required the sun's meridian altitude, and his azimuth at Oporto on the 14th of February.

A Glossary of Terms.

Aberration, an apparent change of place in the fixed stars, arising from the motion of the earth, combined with the motion of light.
Accelerated motion, when the real diurnal motion of a planet exceeds its mean diurnal mottion
Achernar, a star of the first magnitude in the constellation Eridanus.
Achronical rising and setting of a star or planet, is when it rises at sunset, and sets at sunset.
Acubens, a star of the fourth magnitude, marked *a*, in the claw of Cancer.
Adhil, a star of the sixth magnitude in the garment of Andromeda.
Arided, a star of the second magnitude in the tail of Cygnus.
Alderamin, a star of the third magnitude, marked *a*, in the shoulder of Cepheus.
Alamaach, a star of the second magnitude in the foot of Andromeda.
Albireo, a star of the third magnitude near the head of Cygnus.
Alcor, a small star in the tail of Ursa Major.
Aldebaran, a star of the first magnitude in the eye of Taurus.
Aldhafera, a star of the third magnitude in the mane of Leo.
Algenib, a star of the second magnitude in Perseus; also a star in the wing of Pegasus.
Algol, a star of the second magnitude in Caput Medusæ.
Algorab, a star of the third magnitude in the right wing of Corvus.
Alkes, a star of the third magnitude in Crater et Hydra.
Alioth, a star of the third magnitude in the tail of Ursa Major.
Almacanters, imaginary circles, which are supposed to be drawn parallel to the horizon.
Alpheratz, a star of the second magnitude in the head of Andromeda.
Alruccabah, the polar star in the tail of Ursa Minor.
Altitude, the height of any celestial body above the horizon.
Amphiscii, a name given to the inhabitants of the torrid zone, on account of their shadow's falling at one time of the year towards the north pole, and at another time towards the south pole.
Amplitude, the distance of a celestial body from the east at its rising, or from the west at its setting.
Analemma, a projection of the sphere on the plane of the meridian.
Angha, a star of the third magnitude in Aquarius.
Andromeda, a large northern constellation.
Angle, the inclination of two lines meeting in a point,

Anomaly, the distance of a planet from its aphelion, or apogee.
Antœci, a name given to those inhabitants of the earth who live under the same meridian, and at equal distances from the equator, but on opposite sides of it.
Antarctic Circle, a small circle of the sphere, 23° 28′ from the south pole, parallel to the equator.
Antares, a brilliant star of the first magnitude, in the heart of Scorpio.
Antecedentia, a motion of a celestial body, contrary to the order of the signs.
Antipodes, those inhabitants of the earth who live diametrically opposite to each other, and walk feet to feet.
Antiscii, a name given to those inhabitants of the earth who live under the same meridian, but on opposite sides of the equator, because at noon their shadows fall opposite each other. *See Antœci.*
Antlia Pneumatica, the air pump, a new southern constellation below Hydra.
Aphelion, that part of a planet's orbit farthest from the sun.
Apis, the bee, a small modern constellation in the southern hemisphere.
Apogee, that part of the moon's orbit farthest from the earth.
Apparent conjunction of two celestial bodies, when they appear to us in the same degree of the zodiac.
Apparent diameter of a celestial body, its angular diameter, as seen from the earth, measured with a micrometer.
Apparent horizon, the circle that bounds our sight.
Apsis, the aphelion or perihelium of a planet's orbit.
Apus, the bird of paradise, a new southern constellation within the antarctic circle.
Aquarius, the waterman, a constellation of the zodiac in the southern hemisphere.
Aquila et Antinous, the eagle and Antinous, a large constellation in the northern hemisphere.
Ara, the altar, an ancient constellation below Scorpio.
Arc, a part of the circumference of a circle, or a curve line lying between two points.
Arctic circle, a small circle of the sphere parallel to the equator, 23° 28′ from the north pole.
Arcturus, a star of the first magnitude in Bootes.
Argo Navis, the ship Argo, a brilliant constellation of the southern hemisphere.
Aries, the ram, a constellation of the zodiac in the northern hemisphere.
Arietis, a star of the second magnitude in the head of Aries.
Ascending, in astronomy, a term used to denote the rising of a star or planet above the horizon.
Ascending node, that part of a planet's orbit where it crosses the ecliptic northward.
Ascension, (right,) that degree of the equator, reckoned from the

point Aries, which comes to the meridian with the sun, star, or planet.

Ascension, (oblique,) an arc of the equinoctial, contained between the first degree of Aries, and that part of it which rises with the sun or star.

Ascensional difference, the difference between the right and the oblique ascension.

Ascii, a name given to the inhabitants of the torrid zone, because the sun is twice a year in their zenith. Their bodies at these times will cast no shadow.

Aspect, the situation of one heavenly body with regard to another.

Asterism, a collection of stars.

Asterion, the northern hound.

Astrolabe, a stenographic projection of the sphere upon the plane of one of the great circles.

Astrology, anciently synonymous with astronomy; also a pretended art of foretelling future events by the aspects of the stars.

Astronomy, a science treating of the celestial bodies.

Altair, a bright star of the first magnitude in the back of Aquila.

Atmosphere, an elastic fluid, which surrounds the earth.

Attraction, that power by which bodies are made to approach each other.

Auriga, the wagoner, a constellation of the northern hemisphere.

Aurora, the morning twilight, first appearing when the sun is about 18° below the horizon.

Aurora Borealis, meteors appearing in the north.

Austral, southern.

Axis of a celestial body, an imaginary line on which it is supposed to revolve.

Axis, (conjugate,) the shortest axis of an ellipse.

Axis, (transverse,) the longest axis of an ellipse.

Azimuth, the bearing of a heavenly body from the meridian.

Baten Kaitos a star of the third magnitude in Cetus.

Bellatrix, a star of the second magnitude in the shoulder of Orion.

Benetnach, a star of the second magnitude in the tail of Ursa Major.

Betelguese, a star of the first magnitude in the left shoulder of Orion.

Bissextile, or leap year, every fourth year.

Bootes, a brilliant constellation of the northern hemisphere.

Brandenburgium Sceptrum, the Brandenburgh sceptre, a small southern constellation.

Cancer, the crab, a constellation of the zodiac in the northern hemisphere.

Canis Major, the great dog, a beautiful constellation of the southern hemisphere.

Canis Minor, the little dog, a constellation of the northern hemisphere under Gemini.

Canopus, a star of the first magnitude in Argo Navis.

Capella, a brilliant star of the first magnitude in the back of Auriga.

Capricornus, the goat, a constellation of the zodiac.
Cardinal points, the east, west, north, and south points of the compass.
Cardinal points of the ecliptic, the first degrees of the signs, Aries, Cancer, Libra, and Capricornus.
Cassiopeia, a northern constellation, representing a lady seated.
Castor, a star of the first magnitude in Gemini.
Cela Sculptoris, the graver, a small modern constellation of the southern hemisphere.
Celestial, heavenly.
Centaurus, a beautiful constellation of the southern hemisphere.
Centrifugal force, that force by which a body revolving around another, endeavours to recede from it.
Centripetal force, that force by which a body revolving around another, is drawn towards the centre of gravity.
Centre of gravity, that point about which all the parts of a body do, in any situation, balance each other.
Cepheus, a constellation within the arctic circle.
Cerberus, a small northern constellation in the hand of Hercules.
Ceres, one of the asteroids.
Cetus, the whale, a large southern constellation.
Chameleon, a new constellation within the antarctic circle.
Chara, the southern hound in Canes Venatici.
Circinus, the compasses, a small southern constellation at the feet of Centaurus.
Circles of the sphere, imaginary lines surrounding the sphere.
Columba Noachi, Noah's dove, a small constellation of the southern hemisphere below Orion.
Colures, two great circles of the sphere.
Coma Berenices, Berenice's hair, a northern constellation.
Complement of an arc, or an angle, what it wants of 90°.
Conjunction of two bodies, when they appear in the same sign of the zodiac.
Constellation, a cluster of stars, which authors have supposed to resemble the outlines of some animal.
Cor Caroli, Charles' heart, a single star of the second magnitude between Asterion and Chara.
Cor Hydra, a star of the second magnitude in the heart of Hydra.
Corona Australis, the southern crown, a circle of stars around the foot of Sagittarius.
Corona Borealis, the northern crown, a small brilliant constellation in the northern hemisphere.
Corvus, the raven, a small southern constellation in the back of Hydra.
Cosmical rising and setting of a celestial body, when it rises and sets with the sun.
Crater, the cup, a small southern constellation below Leo.
Crepusculum, twilight.

Crux, the cross, a small constellation near the south pole. These stars serve as pointers to the south pole.
Culmination, the passage of a star or planet across the meridian.
Cycle of the moon, a period of 19 years, when the conjunction and lunar aspects, will again bear nearly the same appearance.
Cycle of the sun, a period of 28 years, when the days of the month will again return to the same days of the week.
Cygnus, the swan, a beautiful northern constellation.
Day, (artificial,) the time from sunrise to sunset
Day, (astronomical,) the time between the sun's appearing twice on the same meridian.
Day, (civil,) in the United States and England, it is twice 12 hours, reckoned from midnight to midnight.
Day, (natural,) the time in which the earth makes a complete revolution on its axis.
Day, (sidereal,) the time elapsing between a star's appearing, twice successively on the same meridian.
Declination, the distance of a celestial body from the equinoctial or equator, in degrees.
Degree, the three hundred and sixtieth part of a circle.
Delphinus, the dolphin, a small bright constellation of the southern hemisphere.
Deneb, a star of the first magnitude in Leo.
Depression of a celestial body, its distance below the horizon.
Descending node, that point of the ecliptic where the orbit of a planet is supposed to intersect it in passing from a northern to a southern latitude.
Diagram, a delineation of geometrical figures; a mathematical scheme.
Digit, the 12th part of the diameter of the moon or sun.
Disk, the round face of the sun, or of a planet.
Diurnal, daily.
Dorado, the sword fish, a new southern constellation.
Draco, the dragon, a northern constellation surrounding the pole of the ecliptic
Dubhe, a star of the first magnitude in Ursa Minor.
Earth, the planet in which we live, the third in order from the sun.
East, one of the cardinal points.
Eccentricity, deviation from a centre; the distance between the centre of an ellipse, and either of the foci.
Eclipse, an obscuration of the light of one body, occasioned by the interposition of another.
Electra, one of the Pleiades.
Ecliptic, the earth's orbit round the sun.
Elevation, the height or altitude of any object.
Ellipsis, an oval figure generated from the section of a cone, by a plane cutting both sides of the cone, but not parallel to the base, and meeting with the base produced.
Elongation, the angular distance of a planet from the sun, as it appears to a spectator on the earth.

Emersion, the time when a planet begins to recover its light, after having been eclipsed.
Epact, the difference between a lunar and a solar year.
Ephemeris, a collection of tables containing an account of the daily motions and situations of the planets.
Epoch, see Era.
Equation of time, the difference between solar time, and that shown by a clock.
Equator, a great circle of the sphere, which divides the globe into northern and southern hemispheres.
Equinoxes, those points where the ecliptic cuts the equator; the first degrees of Aries and Libra.
Equuleus Pictoris, the painter's easel, a small constellation of the southern hemisphere under Argo Navis.
Equulus, the little horse, a northern constellation representing a horse's head.
Eridanus, the river Po, a large constellation of the southern hemisphere.
Etanin, a star of the second magnitude in the head of Draco.
Evection, inequality in the motion of the moon.
Faculæ, bright spots frequently seen on the sun's disk.
Firmament, the orb of the fixed stars.
Fixed Stars, those stars that do not appear to change their position.
Focus of an ellipse, a point towards each end of the longer axis of an ellipse, at the distance of half the length of the transverse from either extremity of the conjugate.
Foci, plural of focus.
Fomalhaut, a star of the first magnitude in Australis.
Fornax Chymica, the chymist's furnace, a new southern constellation.
Galaxy, or milky-way, a large band of light encompassing the heavens.
Gemini, the twins, a constellation of the zodiac.
Gemma, or Alphacca, a brilliant star of the second magnitude in Corona Borealis.
Geocentric place of a planet, its position as seen from the earth.
Georgium Sidus, a name given to the planet Herschel in honour of George III.
Gibbous, the shape of the enlightened part of the moon from the first quarter to the full.
Grus, the crane, a new constellation of the southern hemisphere.
Halo, a circle surrounding the sun or moon.
Heavens, the wide expanse in which the sun, planets, stars, and comets are situated.
Heliacal rising and setting of a star or planet, when it emerges from the sun's rays, and appears above the horizon before him, in the morning.
Heliocentric place of a star or planet, its position as seen from the sun.

Hemisphere, half a sphere.
Hercules, a northern constellation.
Hercules, a name given to the star Pollux.
Herschel, Uranus, or the Georgium Sidus, the last planet in the solar system.
Hesperus or *Vesperus*, the name of Venus when an evening star.
Heteroscii, inhabitants of the temperate zones; so called because their shadows fall but one way at noon.
Horizon, a great circle of the sphere dividing the earth into upper and lower hemisphere. The sensible horizon is that which bounds our sight.
Horizontal, belonging to the horizon; parallel to the horizon.
Horizontal parallax, the parallax of a celestial body, when rising.
Horologium, the clock, a new southern constellation.
Hour, the twenty-fourth part of an astronomical day.
Hour-circles, the same as meridians.
Hyades, a group of stars in the head of Taurus; the chief of which is Aldebaran.
Hydra, a large southern constellation, represented as a serpent with a number of heads.
Hydrus, the water snake, a small antarctic constellation.
Hydra Cor, a star of the first magnitude in Hydra.
Hypothesis, a supposition.
Immersion, when a planet enters into a dark shadow, or the moment of an eclipse.
Inclination, an angle which the orbit of one planet makes with that of another.
Indus, the Indian, a new southern constellation under Sagittarius.
Inferior planets, the planets whose orbits are between the earth and sun.
Ingress, the time of the sun's entering into any particular sign.
Intercalary day, the odd day made up every fourth year of the 6 hours over 365 days.
Julian year, the year instituted by Julius Cesar, called old style.
Juno, one of the four Asteroids.
Jupiter, the largest of all the planets.
Kochab, a star of the second magnitude in Ursa Minor.
Lacerta, the Lizard, a small northern constellation near Andromeda.
Latitude of a place, its nearest distance from the equator.
Latitude of a planet or star, its nearest distance from the ecliptic.
Leo Major, the great lion, a constellation of the zodiac.
Leo Minor, the little lion, a new constellation above Leo Major, formed by Hevelius
Lepus, the hare, a southern constellation at the feet of Orion.
Less circles of the sphere, those which divide the globe into unequal parts.
Libra, the balance, a constellation of the zodiac.

Libration, an inequality in the moon's motion whereby one side is more towards the earth than the other.
Line of the Aspides, a line joining the aphelion and perihelion of a planet's orbit.
Lines of Longitude, meridians.
Longitude of a place, its distance east or west from the first meridian.
Longitude of a star or planet, its distance from the first degree of Aries, reckoned on the ecliptic eastward, in signs, degrees, &c.
Lucifer, name given by the Romans to Venus when a morning star.
Luminaries, the sun, planets, stars, and comets.
Lunar aspects, aspects of the moon.
Lunar distances, the moon's distance from the sun or a fixed star.
Lunation, the time from one new moon to another, it being about 29 days 12 hours 44 minutes and 3 seconds.
Lupus, the wolf, a southern constellation near Centaurus, who is represented as piercing it with a spear.
Lynx, a new constellation of the northern hemisphere near Ursa Minor.
Lyra, the harp, a northern constellation.
Maculæ, dark spots appearing on the sun's disk.
Magnitudes, the comparative sizes of the heavenly bodies.
Markab, a star of the second magnitude in the wing of Pegasus.
Mars, the planet next in order from the earth, of a ruddy appearance.
Menkar, a star of the second magnitude in the mouth of Cetus.
Mercury, the planet nearest the sun.
Meridian, a great circle of the sphere, passing through the zenith and poles, and crossing the equator at right angles.
Merope, one of the Pleiades.
Microscope, an optical instrument, by which we are enabled to discover very minute objects.
Microscopium, the microscope, a new constellation of the southern hemisphere below Capricornus.
Milky-way, the galaxy, an innumerable multitude of stars reaching across the heavens.
Minute, the 60th part of an hour or of a degree.
Mirach, a star of the second magnitude in the zone of Andromeda; also a star of the third magnitude in the girdle of Bootes.
Mizar, a star of the third magnitude in the tail of Ursa Minor.
Momentum, the quantity of motion in a moving body.
Monoceros, the unicorn, a modern constellation on the equator, between Orion and Hydra.
Mons Mænalus, mount Mænalus, a small constellation of the northern hemisphere between Virgo and Serpens.

Mons Mensæ, the table mountain, a small constellation within the antarctic circle.

Month, (lunar periodical,) 27 days 7 hours 43 minutes 8 seconds: the time the moon occupies in passing from a point in her orbit to the same point again.

Month, (lunar synodical,) the time taken up between two conjunctions, of the sun and moon; or 29½ days nearly.

Month, (calendar or solar,) the 12th part of a year.—It averages about 30½ days.

Moon, the satellite of the Earth.

Musca, the fly, a small northern constellation near the back of Aries.

Musca Australis, the southern fly, a southern constellation.

Mutual aspects, such as the primary planets make among themselves.

Nadir, a point in the heavens directly opposite to the zenith.

Nebulæ, telescopic stars having a cloudy appearance.

Nocturnal Arc, the arc described by a celestial body from its setting to its rising.

Nodes, two points where the orbit of a planet intersects the plane of the ecliptic.

Nongesimal degree, the highest point of the ecliptic above the horizon, or the 90th degree, equal to the angles the ecliptic makes with the horizon.

Noon, mid-day, the time of the sun's appearing on the meridian.

North, one of the four cardinal points.

Norma, or Quadra Euclidis, a southern constellation.

Nucleus, a name given to the head of a comet.

Nutation of the earth's axis, a libratory motion of the earth, occasioned by the attraction of the sun and moon upon the protuberant matter of the equator.

Oblique, indirect; not perpendicular.

Obliquity, deviation from physical rectitude; deviation from parallelism, or perpendicularity.

Oblique sphere, that position of the globe in which either of the poles is elevated above the horizon any number of degrees less than 90.

Occultation, the obscuration of a celestial body by the interposition of the moon, or some other planet.

Octans Hadleianus, Hadley's Octant, a new southern constellation near the south pole.

Octant, an eighth part of a circle.

Officina Sculptoris, the sculptor's workshop, a new southern constellation below Cetus.

Opposition, the position of the stars or planets when 180° degress distant from each other.

Orbit, the curve that any celestial body describes in performing its revolution around another celestial body.

Oriental, eastern.
Orion, a brilliant constellation near the equator.
Pallas, one of the Asteroids.
Parallax, the angle which the semidiameter of the earth forms with a celestial body.
Parallels of latitude, small circles of the sphere drawn parallel to the equator.
Parallel sphere, the position of the sphere in which the equator is parallel to the horizon.
Pavo, the peacock, a new constellation of the southern hemisphere.
Pegasus, a northern constellation representing a winged horse.
Penumbra, a faint shade surrounding the perfect shadow in an eclipse.
Perigee, that point of the moon's orbit nearest the earth.
Perihelion, that point of a planet's orbit nearest the sun
Periscii, the inhabitants of the frigid zones.
Period, in astronomy, the time in which any phænomenon is completed so as to begin again the same as before.
Periphery, the circumference of any circle or ellipse.
Periœci, those people who live in the same latitude, but on opposite longitudes.
Perseus, a northern constellation represented with a sword in one hand, and a head covered with snakes instead of hair, in the other.
Phases, the different appearances of the enlightened part of the moon or inferior planets.
Phenomenon, a remarkable appearance in the heavens; as eclipses, comets, &c.
Phœnix, a southern constellation, representing a fabulous bird of the ancients.
Pisces, the fishes, a constellation of the zodiac.
Piscis Autralis, the southern fish, a brilliant constellation of the southern hemisphere.
Piscis volans, the flying fish, a modern constellation near the south pole.
Planet, (primary,) a celestial body which revolves around the sun.
Planet, (secondary,) a celestial body that revolves around a primary planet.
Plane, in astronomy often means imaginary surface, as the plane of a planet's orbit.
Planetarium, or orrery, an instrument used to demonstrate the various phænomena of the planets.
Pleiades, a brilliant cluster of stars in Taurus.
Pointers, two stars in Ursa Major, which always point to the pole star.
Polar circles, two small circles of the sphere 23° 28′ from either pole.

Polaris, the pole star, a star of the second magnitude in Ursa Minor.
Poles, the extremities of a planet's axis.
Pollux, a bright star of the second magnitude in Gemini.
Precession of the equinoxes. See Recession of the equinoxes.
Procyon, a star of the first magnitude in Canis Major.
Quadrans Euclidis, Euclid's quadrant, a small modern constellation of the southern hemisphere near Scorpio.
Quadrant, the fourth part of a circle.
Quadratures, or quarters, the position of the moon when 3 signs from the sun
Quartile aspect, the position of two celestial bodies when 3 signs distant.
Ras Algethi, a star of the third magnitude in Hercules.
Ras Alhagus, a star of the second magnitude in Serpentarius.
Rastaben, a star of the second magnitude in the head of Draco.
Radius, half the diameter of a circle.
Recession of the equinoxes, a slow retrograde motion of the two points where the equator intersects the ecliptic.—It equals $50\frac{1}{4}$ seconds a year.
Refraction, the variation of a ray of light from that right line in which it would have passed, had not the density of the medium turned it aside.
Reflection, the return of the rays of light after being repelled or driven backwards.
Regulus, a star of the first magnitude in the heart of Leo.
Repulsion, that power in bodies which prevents the approach of others; the act or power of driving off from itself.
Retrograde, the act of moving backwards; or, a motion in the planets contrary to the order of the signs.
Revolution, the period of a celestial body.
Rigel, a star of the first magnitude in the heel of Orion.
Rising of a celestial body, its appearance above the eastern edge of the horizon.
Robur Caroli, Charles' oak, a new constellation of the northern hemisphere.
Rotation, the motion of a celestial body on its axis.
Sagitta, the arrow, a northern constellation.
Sagittarius, the archer, a constellation of the zodiac.
Saros, Chaldean Saros, 18 years 11 days 7 hours 43 minutes 20 seconds, or 223 lunations; the time in which the same eclipse returns.
Satellites, or moons, secondary planets which revolve around primary ones.
Saturn, one of the primary planets.
Scheat Alperas, a star of the second magnitude in the leg of Pegasus.
Schedir, a star of the second magnitude in Cassiopeia.
Scorpio, the scorpion, a constellation of the zodiac.

Scutum Sobieski, Sobieski's shield, a small northern constellation formed by Hevelius.

Second, the 60th part of a minute.

Serpentarius et Serpens, a northern constellation.

Setting of a planet, its disappearance in the western horizon.

Sextans Uraniæ, Urania's sectant, a modern constellation on the equator near Leo.

Sextant, the sixth part of a circle; a mathematical instrument.

Sextile aspect of heavenly bodies, when they are 60° distant.

Sideral or *Sidereal*, belonging to the stars.

Sign, the 12th part of the ecliptic; or 30 degrees.

Sirius, a brilliant star of the first magnitude in the head of Canis Major.

Situla, a star of the third magnitude in Aquarius.

Solstices, the time the sun enters Cancer and Capricorn.

Solstitial points, the first degrees of Cancer and Capricorn; those points where the ecliptic touches the tropics.

South, a cardinal point in the horizon.

Southing of the stars, &c., the time when they culminate.

Sphere, in astronomy, that concave expanse which invests our globe.

Sphere, (artificial,) an instrument representing the several circles of the sphere in their natural order.

Sphere, (oblique,) that in which the axis and equator cut the horizon obliquely.

Sphere, (parallel,) when the equator as well as all its parallels are parallel to the horizon.

Sphere, (right, or direct,) that which has the poles of the world in its horizon, and the equator in the zenith and nadir.

Spica Virginis, the virgin's wheat-ear, a brilliant star of the first magnitude in Virgo.

Stars, those bodies which shine by their own effulgence.

Stationary, standing still; without motion.

Style, in astronomy, time reckoned from some particular period.

Superior planets, those which revolve without the orbit of the earth.

Syzygy, that part of a planet's orbit in which it is either in conjunction or opposition.

Tangent, a line touching a circle perpendicular to the radius.

Tarandus, the rein-deer, a modern constellation within the arctic circle.

Taurus, the bull, a constellation of the zodiac.

Taurus Poniatowski, Poniatowski's bull, a modern constellation of the northern hemisphere below Hercules.

Telescopic stars, those seen only by means of a telescope.

Telescopium, the telescope, a new southern constellation, formed in commemoration of Herschel's great discoveries with his telescope.

Temperate zones, that proportion of the earth contained between the tropics and the polar circles.

Terminator, an imaginary circle dividing the enlightened hemisphere of the earth from the darkened.

Theory, a plan or system yet subsisting in the mind; a speculative scheme.

Tides, the rising and falling of the waters, caused by the attractive action of the sun and moon.

Time, the measure of duration.

Torrid zone, that part of the earth contained between the tropics.

Toucana, the toucan, or the American goose, a southern constellation.

Transit, the passage of an inferior planet over the sun's disk.

Triangulum, the triangle, a northern constellation of small stars.

Triangulum Australe, the southern triangle, a modern constellation on the antarctic circle.

Tropics, two small circles of the sphere, 23° 28′ on either side of the equator.

Twilight, faint light before sunrising and after sunsetting, occasioned by the refraction of the earth's atmosphere.

Umbra, the total shadow of the sun or moon in an eclipse.

Uranus, the Georgium Sidus, or Herschel, the most distant planet in the solar system, discovered by Dr. Herschel.

Ursa Major, the great bear, a splendid northern constellation.

Ursa Minor, the little bear, a constellation near the north pole resembling Ursa Major.

Vega, the brightest star in Lyra.

Venus, a planet of the solar system, situated between the orbits of Mercury and the earth.

Vertex, that point in the heavens directly over our heads.

Vertical circles, the azimuth circles.

Vesta, one of the new planets.

Vindemiatrix, a star of the third magnitude in the north wing of Virgo.

Virgo, the virgin, a constellation of the zodiac situated on the equator.

Vulpecula et Anser, the fox and goose, a modern constellation in the northern hemisphere.

Xiphias, a southern constellation.

Year, that space of time occupied by a primary planet in performing its revolution round the sun.

Zenith, that point in the heavens exactly over head; the upper pole of the horizon.

Zodiac, a zone surrounding the heavens, in which space all the planets perform their revolution around the sun.

Zone, a division of the sphere contained between two parallels of latitude.

Questions for Examination.

1. Define the term Astronomy, and name those bodies which are called the celestial luminaries.

Of the History of Astronomy.

1. What people were the early cultivators of astronomy ?
2. To what use did the Phœnicians apply this science ?
3 What was the particular object of their observations ?
4. What is related of Thales ?
5 What invention is ascribed to Anaximander ?
6. How did the Greeks improve their knowedge of astronomy ?
7, Did the Romans encourage this science ?
8. By whom has astronomy been brought to its present state of perfection ?
9. Who were the most noted among the ancient astronomers ? When did Pythagoras flourish ? What was his system of the universe ? What planets were known in his time ?
10. When did Ptolemy flourish ? Give a description of his system.
11. During what time was astronomy neglected ?
12. When did astronomy begin to assume a rational appearance ?
13. Who revived the system of Pythagoras ? At what time ?
14. Did the system of Pythagoras meet with opposition ?
15. Did Tycho Brahe oppose the opinions of Copernicus ?
16. Describe the system which Tycho projected.
17. Did it succeed ?
18 What is said of Kepler ?
19. What discoveries is Galileo said to have made ?
20. To whose labours are we indebted for improvements in astronomy ?

Of the Solar System.

1. What system is now received as the true one?
2. What bodies does it comprise?
3. What are the primary planets?
4. Which of them are called asteroids?
5. What is understood by secondary planets?
6. What are comets?
7. What is the centre of the system? In what order do the planets move?
8. What is the orbit of a celestial body?
9. What is understood by the term year? What, by day?
10. What is the axis of a planet?
11. Of what shape are the sun and planets?
12. Define the term globe, or sphere.
13. Why are the sun and planets supposed to be globular?
14. What combines to prove that the earth is globular?
15. What is the zodiac? How divided?
16. What is the ecliptic?

Of the Sun.

1. Can you give a description of the sun? What is its diameter? What, the period in which it revolves on its axis?
2. When is the sun nearest to the earth?
3. Why is it hotter in summer than in winter?
4. What is supposed to environ the sun? and how are its light and heat occasioned?
5. Give the supposed extent and density of the atmosphere surrounding the sun.
6. What occasions the appearance of the sun's rising in the east, and setting in the west?
7. When is it noon at any place? and when midnight?
8. How has the period of the sun's revolution been ascertained?

Of Mercury.

1. Give some description of Mercury.
2. What is his diameter?
3. What, the time of his revolution?
4. What, the length of his day?
5. Where does he cross the plane of the ecliptic?
6. What is the velocity of Mercury? What, his eccentricity?

7. What is understood by eccentricity in astronomy?
8. What is said of Mercury when viewed through a telescope?
9. What is called a transit? How many have been observed?
10. What is meant by the sun's disk?

Of Venus.

1. Give some description of Venus.
2. What is her diameter? and what, her circumference?
3. What, her mean distance from the sun?—her eccenticity?—her movement in orbit?
4. What time does Venus take in performing an annual revolution?—a diurnal rotation?
5. What appearances has she similar to those of the moon?
6. Do transits of Venus ever occur? When was one observed?
7. When will any happen again?
8. When is Venus a morning star?—an evening star?
9. What have been observed on the disk of this planet? what is the supposed magnitude of its mountains, compared with those of the earth?
10. Where does the orbit of Venus cut the plane of the ecliptic?
11. By what is Mercury surrounded?

Of the Earth.

1. Give some description of the earth.
2. What is its distance from the sun? What, its movement in orbit?
3. What is the difference in length between the polar and the equatorial diameter of the earth? What is the eccentricity of the earth?
4. What is the circumference of the earth, measured round the equator?—through the poles?
5. In what time is its sidereal revolution performed?—its tropical revolution? its revolution on axis?
6. What is meant by the sidereal revolution of the earth? and what, by the tropical?
7. What is the recession of the equinoxes?
8. What is the length of the natural day?
9. What is a meridian?
10. How many motions has the earth, and what are they called?

11. What produces the change of seasons?—the succession of day and night?

12. What is called the obliquity of the ecliptic?

13. How great can the sun's greatest declination be?

14. How is the apparent declination occasioned?

15. When are the days the longest, and when the shortest, in each hemisphere respectively?

16. What are called the solstitial points?

17. At what time are the days and the nights equal?

18. When is the earth said to be in its equinox?

19. What is the sun's declination at the solstices? and what, in the equinoxes?

20. Mention those days on which the sun enters the first degree of each sign of the zodiac respectively?

21. What surrounds the earth?

22. What attends the earth in its revolution about the sun?

Of Mars.

1. Give some description of Mars.

2. How does this planet appear when viewed through a telescope? How does it appear to move?

3. In what time does it perform an annual revolution? and at what distance from the sun? What is its diameter?—the eccentricity of orbit? How rapid is its movement?

4. What is the length of its day?

5. What angle does the orbit of Mars make with the ecliptic? Where is the place of his ascending node?

6. At what time is Mars seen?

7. At noonday where is he sometimes seen? What do you infer from this circumstance?

8. How would the earth appear to the inhabitants of Mars?

Of the four Asteroids or Minor Planets.

1. Give some description of Vesta.

2. What is the length of its diameter? and what, its mean distance from the sun? What is the length of its year? and what, the velocity of its movement? How great is the eccentricity of its orbit?

3. When and by whom was Juno discovered? Give some description of it.

4. What is its diameter? and what its distance from the sun? What is the length of its year? Its eccentricity?

5. Give some description of Ceres.

6. What is the length of its diameter? and what, its dis-

tance from the sun? In what time does it perform its annual revolution? and at what rate? How great is the eccentricity of its orbit?

7. What is the height of its atmosphere?

8. By whom and when was Pallas discovered? What is its appearance?

9. What is the estimated diameter of Pallas? and what its distance from the sun?

10. In what time does it revolve around the sun? and what is its eccentricity?

11. Why does the orbit of Pallas cross that of Ceres?

Of Jupiter.

1. What is the situation of Jupiter?

2. What is his diameter? and what, his distance from the sun?

3. What is the length of Jupiter's year? and what is his hourly motion?

4. What is the length of his day?

5. Why no change of seasons?

6. What season in the polar regions of Jupiter? and what about his equator?

7. How is his appearance, compared with Venus?

8 When does Jupiter appear as a morning star?—an evening star?

9. What angle does he form with the plane of the ecliptic?

10. How much larger does the sun appear to us, than to those who inhabit Jupiter?

11. Jupiter appears to be surrounded with belts—give some description of them How has the time of Jupiter's rotation on its axis been ascertained?

12. What attend this planet? What benefit are they to it?

Of Saturn.

1. How is Saturn situated?

2. What is the length of his diameter? and what is his circumference?

3. What is the length of his annual revolution? and how great is his velocity?

4. What angle does Saturn's orbit form with the ecliptic? How great is his eccentricity? Where his ascending node? and where, his descending node?

5. What is the length of his day, or daily revolution?

6. What is his appearance to the naked eye?

7. Describe his appearance, as viewed through a telescope.

8. What things are said concerning Saturn's ring?

9. Describe the distances and breadths of the rings.

10. What are Saturn's zones similar to?

11. What conjectures have been entertained respecting Saturn's ring?

12. Describe Saturn's satellites, namely, their number, and by whom discovered?

Of Herschel.

1. Give some description of this planet.

2. What is its diameter, and its mean distance from the sun?

3. What is the length of its year? Has the time of its daily revolution been ascertained? How great is its movement in orbit?

4. How great an angle does Herschel's orbit form with the plane of the ecliptic? What is its eccentricity? Where is its ascending node?—its descending node?

5. How can a planet be distinguished from a fixed star?

6. How many moons attend Herschel?

7. How much more heat does the earth derive from the sun than Herschel does?

Of the Secondary Planets.

1. What is a secondary planet?

2. What is observed respecting its gravitation and movement?

Of the Moon.

3. Describe this planet.

4. How far is it from the earth? and how far from the sun? In its orbit how many miles does it move an hour?

5. In what time does it turn once around on its axis?

6. What are meant by the phases of the moon? How does the moon sometimes appear?

7. When is it new moon?

8. When, full moon?

Of the Satellites of Jupiter.

9. What makes up for Jupiter's deficiency of light from the sun? Who discovered Jupiter's satellites?

10. How far from Jupiter is his first satellite? and in what time does it revolve around him?

11. How far, the second ? and what is the time of its revolution ?

12. How far, the third ? and what is the time of its revolution ?

13. How far the fourth ? and what is the time of its revolution ?

14. How are Jupiter's satellites important in finding the longitude of places ? Which is considered the best for this purpose ? and why ?

15. In what work are the immersions and emersions of Jupiter's satellites found calculated ?

16. Describe the angles of the orbits of Jupiter's moons, as seen from the earth.

Of the satellites of Saturn.

17. How many satellites has Saturn ?

18. Describe the distances, and the time of revolution of the first satellite.

19. —of the second satellite.

20. —of the third satellite.

21. —of the fourth satellite.

22. —of the fifth satellite.

23. —of the sixth satellite.

24. —of the seventh satellite. What has been observed of this satellite.

Of the satellites of Herschel.

25. How many satellites has Herschel ? and by whom were they discovered ?

26. Mention the time occupied by the first satellite in revolving around its primary ; and the distance from its primary, at which it revolves.

27. Mention the distance, and the time of revolution, of the second satellite. When was it discovered ?

28. In what time does the third perform its revolution ? when was it discovered ?

29. How far from Herschel is the fourth ? and in what time does it revolve ? When was it discovered ?

30. In what time does the fifth complete its revolution, and at what distance ? When was it discovered ?

31. In what time the sixth ? and at what distance ?

32. What is observed respecting the orbits of Herschel's satellites ?

Of Comets.

1. What are comets ? What is their appearance ?

2. Do they ever approach near to the sun ?

3. What is said concerning their movement?

4. What was the opinion of the ancients respecting comets?

5. What conclusion did Newton form with regard to comets?

6. When is the movement of comets accelerated? when retarded?

7. How near to the sun did the comet of 1680 approach?

8. What appears to affect comets?

9. How many comets have been observed? the elements of how many have been ascertained?

10. How many comets appear to have passed between the orbit of Mercury and the sun?—between the orbit of Mercury and that of Venus?—Venus and the earth?—the earth and Mars?—Mars and Ceres?—Ceres and Jupiter?

11. What is said of the magnitudes of comets?

12. What is said of the bright train of comets?

13. The system of comets somewhat in obscurity—upon whose opinions must we depend respecting them?

Of the Fixed Stars.

1. Give some description of the fixed stars.

2. What difference is there in appearance between the fixed stars and the planets?

3. What motion do the fixed stars appear to have?

4. Why does the north star appear immoveable?

5. How many stars are visible to the naked eye? why does there appear to be such a multitude?

6. Are the fixed stars any larger in appearance when observed through glasses?

7. How have these stars been divided?

8. What stars are called unformed stars? what periodical stars?

Of the Constellations.

1. What is a constellation?

2. Into how many constellations are stars classed? and how many in the zodiac? in the northern hemisphere?—in the southern hemisphere?

Of motion.

1. What is the definition of motion? With how many kinds of motion are we principally acquainted?

2. What effect upon bodies has heat? and what has cold?

3. In the consideration of motion what things must be attended to?

4. In a mechanical sense what property does every body possess?

5. If not resisted how will a body move when put in motion? How is velocity of motion estimated?

6. When a body tends to some particular point, what will be its motion? what will produce a curvilinear direction?

7. What will be the motion of a body with respect to its moving force?

8. What will be the motion when several powers are differently applied at the same time?

9. How many forces act upon a body moving in a curvilinear direction?

10. What is called the centrifugal force? and what the centripetal force?

11. What is called the centre of gravity of a body?

12. Where may the weight of a body be considered as centered?

13. What is the common centre of gravity of any two or more b dies?

14. How may motion be divided? What is real motion? What is apparent motion?

Of Eclipses.

1. What is an eclipse?
2. How do you account for the appearance of an eclipse?
3. How many kinds of eclipses are there?
4. What is an eclipse of the sun? and how is it occasioned?
5. When do eclipses of the sun happen?
6. What is a partial eclipse?
7. What is a total eclipse?
8. When will an eclipse of the sun be central?
9. What is an annular eclipse?
10. What is an eclipse of the moon?
11. Describe the figure of the earth's shadow.
12. What is a partial eclipse of the moon?
13. What phenomenon would occur, if the earth's orbit and the moon's were in the same plane? What are called the moon's nodes?
14. What is observed of the eclipses of Jupiter's satellites?

Of Tides.

1. What is tide?
2. How often do the tides ebb and flow every lunar day?

3. How much of the earth's surface is covered with water?

4. What space of time does the tide occupy in ebbing and in flowing?

5. What is observed respecting the time of high water?

6. How much greater is the influence of the moon upon the tides than that of the sun?

7. How many kinds of tides are there? and what are their effects?

8. When do the flux and reflux of the tides become spring tides? When neap tides?

9. When do the greatest tides happen? Why?

10. What is said of the tides when the moon is in the equator? and what when she declines?

11. How are tides retarded? and what is the effect?

12. What is observed of the tides of the German ocean?

13. Why have lakes no tides?

14. What is said of the elevation of tides in the Mediterranean and the Baltic sea?

15. Where do the tides rise very high?

Of Atmosphere.

1. What is atmosphere? To what is it necessary?

2. To what height is the atmosphere of the earth perceptible? Of what does it consist?

3. What is the pressure of the atmosphere upon every foot of the earth's surface?

4. What is the figure of the atmosphere?

Of Wind.

1. What is wind? To what cause may we attribute the wind?

2. What kinds of winds are there?

3. What is said of permanent winds? What are these called by navigators?

4. Describe the periodical winds.

5. What are variable winds?

6. Describe the Hermattan.

7. Where does the Sirocco blow? What does it resemble?

8. What is said of the Samiel?

9. What, of the Simoom?

Of Climates.

1. What is a climate?

2. How many climates between the equator and polar circles?—from each polar circle to its pole?

Of the Aurora Borealis, Milky-way, and Zodiacal Lights.

1. What is the Aurora Borealis ?
2. What is its general appearance ?
3. To what cause is the Aurora Borealis attributed ? Is it ever seen in this country ?
4. Where is the light of it the greatest ? What is the supposed extent of its streaks ?
5. What is the Galaxy, or Milky-way ?
6. Of what is it composed ? How many did Herschel enumerate ?
7. What is the Zodiacal light ? At what time does it appear ? What is its form ?

Of Time.

1. What is time ? and how is it divided ?
2. What is a year ? How many kinds ?
3. What is a tropical year ?
4. What a sidereal or astral year ?
5. What is the length of a common year ?
6. What are the divisions of a common civil year ?
7. What is a day ? and how divided ?
8. What is a natural day ?
9. What a civil day ? How is it reckoned in the United States and in England ?
10. What is an artificial day ?
11. What, an astronomical day ? How reckoned ?
12. What is a sidereal day ?
13. What is an hour ? a minute ? a second ?
14. What is mean time ?
15. What, apparent time ?
16. What is equation of time ?

Of the Globes.

1. How many kinds of artificial globes ?
2. Describe the terrestrial globe.
3. What is the celestial globe intended to represent ? How is its motion ?
4. Of what are globes composed ?
5. What is the axis of the earth ? How represented ?
6. What are the poles of the earth ? What is called the north pole ?—the south pole ?
7. How many circles are marked on the globe ? How do the great circles divide it ? how, the small circles ?
8. What are the small circles ? How is the tropic of Cancer drawn ? and how, the tropic of Capricorn ? Where is

the arctic circle ? and where, the antarctic ? What is the direction of these circles with respect to the equator ?

9. What is observed of the circles of the sphere ?

10. What is the horizon ? and how does it divide the globe ?

11. How many circles are described on the face of the horizon ? How is the first marked ? the second ? The third contains what ? the fourth, what ? What does the fifth contain ? What, the sixth ? the seventh ? the eighth ?

12. What is the brass meridian ? and how is it divided ? How does it divide the globe ?

13. What is the equator ? and how does it divide the globe ?

14. How is longitude marked ? How is latitude reckoned ?

15. What is the ecliptic ?

16. What angle does it form with the equator ? and what are the points of intersection called ? What are marked on the ecliptic ?

17. What are the colures ? What are the equinoctial points ? and what, the solstitial ? What do these divisions mark ?

18. What is the quadrant of altitude ?

19. What is the hour circle ? and what the index ?

20. Parallels of latitude are what ?

21. What are circles of longitude ? What is the first meridian ?

22. Describe the extent of the zodiac ?

23. At what rate does the sun move through the zodiac ? What signs are called northern signs ? what southern signs ? what is the greatest declination that the sun can ever have ? what, a star ? what, a planet ?

24. Describe the analemma.

THE END.